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Reservoirs for Miami Valley

THE consulting engineers reporting on the flood protection plans in the Miami Valley endorse fully the scheme proposed, consisting of reservoirs and moderate channel improvements. The report, printed on page 132, is to the point throughout and step by step the plans of the Morgan Engineering Company are endorsed, even to the statement that the improvements tentatively outlined would have furnished protection against a flood considerably larger than that of March, 1913. With this definite endorsement of the plans work should proceed with confidence as soon as satisfactory enabling legislation is secured.

False Theories about Electrolysis

A WORD of warning is not amiss regarding a book now being rather widely circulated, which advances false theories on electrolysis and protective methods. While those who have followed the subject closely will at once detect its errors, the chance that it may fall into the hands of those not conversant with the subject warrants giving it notice that may invest it with a dignity of which it is totally undeserving. The book is entitled "Electrical and Lighting Engineering" and is written by Henry W. Spang. The imprint is simply "New York," without name of publisher or address of author. Engineers who cross its trail should guard their professional brethren against it.

Approval of the Senate

THE plum crop in Washington must indeed have been slim this year when $3,300 civil engineerships are placed in the political arena. The Alaskan railway bill was amended in the Senate so as to require that august body's approval of the appointment of civil engineers receiving over $3,000 per annum. There is hope that by the time the House finishes with the measure and the conference has considered it the rodmen may come within the purview of the higher chamber. So great is the solicitude of the Senate for the qualifications of the Nation's servants! The sterner stuff required of Arctic railway builders is not apt to be found among those most likely to command the hearty approval of the Senate.

Panama-Pacific Exposition

THE attitude of England and Germany toward the Panama-Pacific exposition and the rapid progress being made on the exposition structures have resulted in securing much publicity for San Francisco's big show. In the notices, however, a feature which to this journal is especially important has generally been overlooked—that the exposition aims primarily to be educational, and therein differs from all its predecessors. Not only are intending exhibitors urged to prepare educational exhibits but assistance is given them in so doing. In fact assignments have been denied those who were content with conventional displays. The educational ideas are running chiefly in the direction of the manufacture of the product, though the plans are naturally as varied as the products and the resources of those arranging the exhibits. With this feature as the chief characteristic there is every reason to believe that the exposition will draw a large attendance, for the spectacular features are to be fully equal to those of other great exhibitions.

The President and Holding Companies

SELDOM has a message of the President been so favorably received as that on the trust problem, read before Congress last week. It was soothing and reassuring—at least in its immediate effect. More careful consideration, however, has raised doubts in many quarters, particularly with regard to the abolition of holding companies. The President, quick to sense the public's attitude, has, therefore, endeavored to make clear that the restriction of holding companies is to apply only when they are of their nature monopolistic. In other words, a holding company controlling subsidiaries that naturally are competitors would immediately fall under suspicion, but one controlling a manufacturing company and various subsidiaries owning the real estate used by the factory, making packages for the main company and building parts for it would not fall under the prohibition. Presumably the same principle would apply to the holding of directorships. Evidently the entire abolition of the holding company would lead to absurdities. It is well that the President has spoken.

Duplicated Educational Facilities

THE hearty approval expressed in educational and engineering circles regarding the Harvard-Technology merger serves to throw into relief the absurd duplication of expensive equipment in some of the Middle Western and Far Western States. Not content with supporting one engineering school, a number of them have two institutions, giving ostensibly identical courses of instruction. In colleges of literature duplication does not involve so much waste as in engineering, for the chief item of first cost is classroom space, which is needed practically in proportion to the number of students. In engineering, however, much expensive equipment is necessary, which, even in the larger institutions, is used only a very small part of the day or year. Its "efficiency of use" would be considerably increased by consolidation of the colleges referred to. The State of Montana has seen the absurdity and has transferred its engineering work from the agricultural college to the University of Montana. The example of the two private institutions at Cambridge, which, unlike duplicating State schools, do not take money out of one pocket, should stir Western engineers and engineering professors to action.

Shackleford Good Roads Bill

THE "good roads" following is so strong that certain Congressmen have not hesitated to attempt to make the issue carry a pernicious rider, even while itself astraddle one of the big appropriation bills. The postoffice appropriation bill, as planned by Mr. Moon, was to carry the latest Shackleford good roads bill, calling for the expenditure of $25,000,000 annually, and also a rider taking 2400 positions out of the civil service. Under this clever plan congressmen opposed to the latter vicious section would have been obliged to vote against "good roads," a sad predicament to be in when newspapers far and near are clamoring for the Government's money to build local roads. Fortunately, the committee on rules refused to accept the plan and the Shackleford bill will now stand on its own merits. Of these it has some, as Federal aid proposals go, but it does not provide means for the Government to ascertain how the moneys given to the states are used. It should be defeated. This journal has made it plain that it does not favor the use of Federal funds for extensive road building. This is the duty of the counties and the states. Nevertheless, the demand is so great that some Federal aid is inevitable, and the best policy, therefore, is to try to guide legislation into the proper channels. But the Shackleford bill, containing no provision for the Government determining how the money is spent, is not in the "proper channels." Until such provision is made, not merely by direction to the Secretary of Agriculture, but by appropriating the necessary funds for the supervision, the bill should not be passed. The measure in its present form is vicious.

Saving Time at Conferences

FAILURE to appreciate the importance of business methods in conducting engineering conferences is a frequent source of wasted time and corresponding increased general expense. Attempts to assemble busy officials by slow mails, inadequate stenographic service, insufficient telephone facilities, lack of care in preserving preliminary estimates and drafts of contracts, distributed responsibility for papers originating within the conference room, and a parsimonious use of the photostat or blueprinting equipment—all tend to draw out the proceedings and delay the progress of other matters held in abeyance. Much good may be accomplished by assigning to some one official of executive ability oversight of these routine duties, with the dual object of making the conference a success through adequate preparation and the maintenance of a prompt and accurate record of its proceedings. In many cases time can be saved by encouraging the attendance of assistant engineers more familiar with details than their chiefs; in other instances a little extra effort spent in putting tabular material into diagrammatic form in advance of the meeting, the use of multiple head telephones at the conference table and the employment of the dictaphone will save half and quarter hours, which mean hundreds of dollars in the administration of a property extending over a wide territory. It is difficult to estimate the indirect cost of massing high-priced officials at a conference chamber perhaps hundreds of miles from their respective offices. Operating conditions change from hour to hour in plants and railroad divisions, and every reasonable method of shortening meetings attended by engineering executives, designers, and advisory experts deserves consideration.

A Bigger Job Than the Canal

MAYOR MITCHEL of New York stirred up the public at large no less than the engineering profession by announcing on Jan. 23 that, under certain conditions, Colonel Goethals would become police commissioner of New York. A reading of the colonel's letter to the mayor, however, will not carry to the outsider the impression it conveyed to Mr. Mitchel. It makes it plain that Colonel Goethals will stay on the Isthmus, and now comes his appointment as Governor of the Canal Zone with full authority, the new régime to become effective April 1. Nevertheless, the letter does indicate a favorable attitude toward the mayor's offer. If New York's police problem is solvable under present conditions Colonel Goethals is the man for the job. It is, however, a thankless and fearful task, as the disclosures following the Rosenthal murder showed. Every known type of vice is organized to fight the police and within the department itself is treachery and supineness—bought by the money coming from the vices which the policeman's oath pledges him to suppress. To free the organization from its fetters, to oust the scoundrels who use their authority to grow fat on the crimes they should arrest, to instill ideals and an esprit de corps that will prevent return to the present practices are tasks more stupendous than the building of the canal. The destruction of "the system" compares with the digging of Culebra. It is interesting to note that one of Colonel Goethal's objections to the position is its lack of autocratic power—dismissals being reviewable by the courts. The mayor hopes to remove the objection so that the "benevolent despotism" of the Zone, which promises to become as famous as any other feature of the canal's construction history, may be tried in New York. One other event of the week lends added interest to the subject. The Senate has passed the Alaskan railway bill —with an amendment providing that the appointment of all civil engineers receiving over $3,000 per annum must have the Senate's approval. At the same time it has been urged that Colonel Goethals be placed in charge of the construction of the road, if authorized. Evidently the Senate has not heard of the "benevolent despotism" or does not expect the colonel will take the job.

Depreciation Report Recommitted

IT is fortunate that at the recent annual meeting the special committee of the American Society of Civil Engineers on valuation for the purpose of rate-making requested that its report be referred back and that a meeting be arranged at which the document can be discussed and the many written discussions already submitted be read. By so doing a strenuous argument was avoided and evidence was given that the committee was of open mind, willing to reconsider such sections as were protested against. While no statement of the reasons for the motion was made, the action was undoubtedly due to the opposition to the committee's views on depreciation—views that in the discussion of the recent papers by Messrs. Wilgus and Alvord were shown to be in disfavor among prominent members of the society who have given much study to the subject. It is not too strong to say that—if discussion before the society is an index—civil engineers are not in favor of the "cost of reproduction less depreciation" theory of valuation as a basis for rate-making, but are strongly in favor of the "cost of reproduction new" theory. Undoubtedly the experience of members of the committee with waterworks properties had much to do with the views advanced. They are, however, at variance with the expressed sentiment of the members of the society and the regulations of most public-service commissions. It is not too much to expect, then, that when the report is again presented the section on depreciation, as far as it concerns the basis for valuation, will be radically rewritten.

Broadening Pavement Specifications

THERE will be little or no profit derived from recent discussions of asphalt specifications unless such specifications are in some way improved as a result. In political agitations it is to be expected that the search will be for a victim rather than for a remedy, but this should not apply in engineering matters. Not a few experienced engineers and officials have been found who say plainly that they do not care how specifications are drawn, or whether the requirements are empirical or practical, so long as the specifications describe the materials wanted in such a way that there is no chance of substitution. One of these engineers, with gift of expression as well as strong convictions, has said that "a requirement that the asphalt should turn pink when placed in attar of roses" would have his hearty approval if it served to describe the material which he knew by experience would "do the work." Of course this engineer would agree that the behavior of asphalts when placed in attar of roses had no bearing upon their qualities as paving materials. His point is that this is as good as any other test to distinguish a particular bitumen. On the other side are those who claim that specifications should be limited to requirements which cover the valuable characteristics of bitumens, which are assumed to be disclosed by more elaborate laboratory tests.

Without attempting at this time to settle so radical a difference of opinion, there is a new thought that is worth consideration in specification making. It is this: More attention should be given to pavements and roads as a whole and to what they are in place and ready for service. At present in drawing specifications for bituminous pavements ingenuity is exhausted in describing the bitumen—one of the raw materials—before it is in place, whereas the whole mixture in place containing the bitumen as part of a finished product is really the important thing. What emphasizes this factor in specification making is that good and bad streets and roads are constantly being built with bitumens which appear to be identical so far as the chemical and physical tests usually mentioned in specifications are concerned.

Whatever may be the ultimate decision, therefore, as to the best method of drawing specifications for asphalt pavements, it is worth while to consider broadening them so as to take into more strict account what the whole pavement—not a part of it—should be; and also to make certain that the bituminous part, after it is in a pavement or road, has the characteristics most necessary to secure good results. This is more important than the characteristics of raw materials or their behavior before they are put to the use for which they are ultimately intended.

Funds for the Bureau of Standards

IT is admittedly a thankless task to apportion the funds which Congress votes annually from the National treasury. No matter how carefully the requests are considered or how desirous the members of a subcommittee may be to distribute moneys where most needed there is sure to be dissatisfaction. While intrinsic merit evidently plays some part in the apportionment, the number and influence of the supporters are likely to have greater weight with the subcommittee.

In seeking a standard for judging the importance of the activities of the Government, should not the influence of the particular appropriation on the safety of life and property be considered an important factor? Judged by this standard, the request of the Bureau of Standards for funds with which to prosecute research in materials of construction assumes an importance far transcending new public buildings or river and harbor improvements. It is certain, however, that where one man will write to his Congressman urging the intrinsic merits of the requests of the Bureau of Standards a hundred will be found who will gladly use their influence to secure a new public building or an enlarged waterway.

It cannot be too strongly emphasized that the investigations of materials of construction now under way and proposed by the bureau are of the very highest type of conservation. They concern not undeveloped mines and water powers but the integrity of structures, on which depend the lives of millions.

In each of the two last years the bureau has asked for $30,000 for the general operating expenses in connection with these investigations. This appropriation has been granted in the past, and a similar amount is requested this year. In addition, however, $100,000 was asked in 1912 and $125,000 in 1913 for special investigations and equipment. On both occasions the amount was scaled down to $75,000 by the subcommittee on appropriations dealing with the Legislative, Executive and Judiciary Bill. Now again the bureau has requested $125,000 for continuation and expansion of its structural work. This includes investigations of concrete, brick and steel columns, cement, properties of concrete, paint, oils and varnishes. It is also proposed to investigate the properties of brick and stone—a much needed work. Great advances have so far been made by the bureau, and the importance of the studies to the public is such that the full amount asked for should be appropriated in order that the work may go forward. If the bureau were already fully organized and all of the lines of investigation were well in hand, small yearly increases would probably be satisfactory. But it must be remembered that this is a rapidly developing work. The bureau is now getting its start, and for some years to come its appropriations, if the greatest good is to be reaped from the work, will have to be increased at a goodly annual rate. Moreover, it should be borne in mind that the funds requested are principally needed in order that additional qualified men may be secured to operate to full capacity the equipment which the bureau already owns.

In one of the other bills which will be under consideration at the present session—the Sundry Civil Bill—an appropriation of $50,000 will be asked in order to purchase a site for housing the equipment now temporarily located in some of the buildings of the War Department at Pittsburgh. In the same bill will be a request for $75,000 toward a building to be erected on this site.

It is quite customary for citizens interested in measures of any sort to exert their influence by bringing the matter to the attention of their respective Congressmen. Is there any reason why engineers should not do likewise, particularly when a measure so vital to the interests of the community at large is at stake? By united action it should be possible to prevent the requests being cut down, as was done in 1912 and 1913.

Pollution of the Great Lakes

THE treaty between the United States and Great Britain signed Jan. 11, 1909, provides that boundary waters "shall not be polluted on either side to the injury of health or property on the other." An International Joint Commission has been investigating the pollution in these waters, and a report of field work, abstracted on another page, has just been made.

The report shows a very painstaking and thorough examination of the extent of bacterial pollution. The commission finds that the great bulk of the water of the Great Lakes remains in its pristine purity, but that dangerous sewage pollution exists at certain points in the lakes and in the connecting waterways. Most of this comes, of course, from the sewage discharge of cities, and some from steamboats. The commission also finds that practically all drinking-water supplies from the lakes must be adequately purified to make them safe; they also find that where pollution is great, hypochlorite treatment is often ineffective.

On the basis of their investigations the next problem before the commission is to determine "in what way or manner it is possible or advisable to remedy or prevent the pollution of these waters" within the limits of the intent of the Treaty of 1909. This is indeed a large problem of many aspects. The basic question is whether or not the boundary waters shall be maintained in such condition that they shall be suitable for drinking-water supplies without any purification. That such a uniformly high standard is in all cases possible of attainment is very much doubted, and if it should be possible it would not always be worth the effort. A very well balanced statement may be found in the report of the British Royal Commission on Sewage Disposal, for 1908, in referring to their river waters. It may be equally well applied to our boundary waters. That commission states:

"We are satisfied that rivers generally, those traversing agricultural as well as those draining manufacturing or urban areas, are necessarily exposed to other pollutions besides sewage, and it appears to us, therefore, that any authority taking water from such rivers for the purpose of water supply must be held to be aware of the risks to which the water is exposed, and that it should be regarded as part of the duty of that authority, systematically and thoroughly, to purify the water before distributing it to their customers.

"Apart from the question of drinking waters, we find no evidence to show that the mere presence of organisms of a noxious character in a river constitutes a danger to public health or destroys the amenities of the river. Generally speaking, therefore, we do not consider that in the present state of knowledge we should be justified in recommending that it should be the duty of a local authority to treat its sewage so that it should be bacteriologically pure."

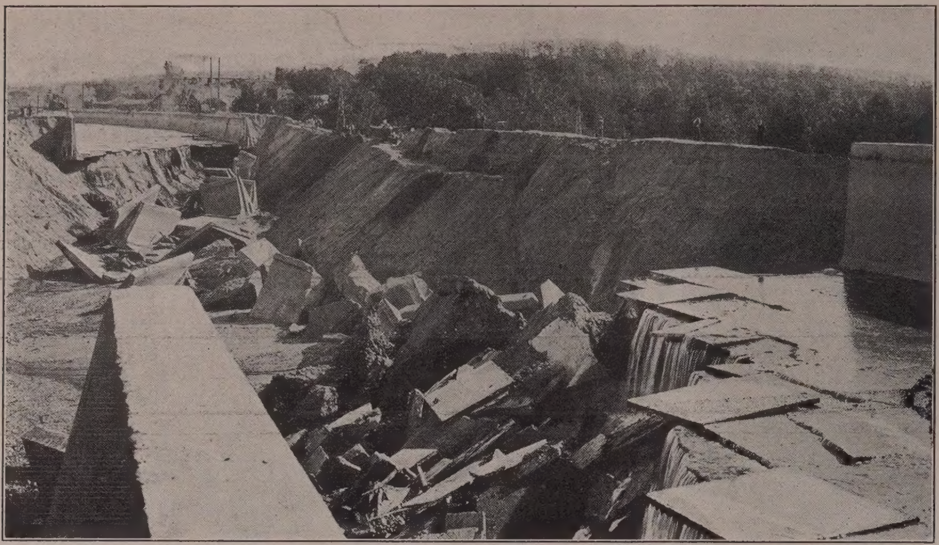
On the other hand, there may be places where pollution is so gross that an undue burden is placed on water purification plants, and the best of these plants may at times fail to make the water absolutely safe. For such conditions the sewage should be subjected to such reasonable amount of treatment as to leave the water, while not pure from a bacteriological standpoint, at least reasonably clean, so that it can be readily purified for use as a domestic supply.

The amount of such treatment is a matter to be determined after consideration of local conditions. It requires for each place a study of the amount and character of the sewage discharged, the amount of diluting water, the nature of the water currents, the effect of wind on these water currents, the effect of stratification and many other special features. It requires, too, a study of the costs of various purification methods when applied to the local conditions, and the results that can be obtained.

Besides this careful engineering examination of the sewage treatment problems of these cities on boundary waters, the commission must very carefully consider the views of the officials and the people of the cities interested. It is fundamental that any rules established which are not in accord with the enlightened public sentiment of the communities on which they are imposed will fail of effect, and for the commission's efforts to lead to practical results it must consider this local public sentiment and see to it that its rules will be such that the municipal authorities and the taxpayers can appreciate their reasonableness.

After such a detailed study of the special features presented by the various localities interested, of the amount of purification which can to advantage be insisted on, and its cost, the commission can formulate a general policy and a set of standards. These standards, to be general in their nature, ought to specify, not the degree of purification which the sewage discharge of any city under the diverse existing conditions must receive, but rather the degree of pollution which is to be permitted in the lake or river water into which the sewage effluent is discharged. A similar standard has been adopted by the British Royal Commission in its Eighth Report.

A report to the National Association for Preventing the Pollution of Rivers and Waterways by its committee on standards, dated Oct. 22, 1912, printed in the Engineering Record of Nov. 2, 1912, page 485, considers this problem in a very general way. The field work report of the commission gives the needed objective data on existing conditions. The next step is to get the views of the interested communities as to existing conditions, and their ability to better them. The final step will be to correlate these various data and opinions in the light of the best expert sanitary knowledge, and to establish an acceptable standard.



Break in Embankment and Trough at Irondequoit Creek Crossing

Concrete Troughs on the Barge Canal

Description of Construction Used on Three High Embankments, and of Break and Temporary Repair of Irondequoit Creek Crossing

By GEORGE C. MILLS
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THREE concrete troughs carry the New York State Barge Canal across creek valleys in the western part of the State. The longest crossing is over Irondequoit Creek, 7 miles east of Rochester; the second in length is at Holley, near the eastern border of Orleans County, and the third is at Eagle Harbor in the same county. The Holley trough, 104 ft. wide and 1100 ft. long, afterward extended to a total length of 2200 ft., and that at Eagle Harbor, 600 ft. long and 94 ft. wide, have been completed and in service, and neither leakage nor settlement have appeared. The Irondequoit trough, originally built to a length of 3800 ft., suffered a serious break in 1912, after it had been in commission for two seasons, the accident occurring at the crossing over the Irondequoit Creek culvert, at a point where the Barge Canal follows the line of the Erie Canal. Since then navigation has depended upon a temporary wooden flume built across the break, and the plan of ultimate repairs has not as yet been announced.

IRONDEQUOIT TROUGH

The Erie Canal crosses the broad depression of the Irondequoit valley upon an embankment over which the standard prism with 7-ft. draught is continued, but with the usual slope walls replaced with wooden planking. The embankment reaches a maximum height of about 80 ft. The alignment has a curvature greater than is allowable on the Barge Canal, and the draught of the latter being 12 ft., a new prism of greater resistance and better alignment was essential. Decision was made early in the preliminary surveys to abandon the old route and to adopt the more direct course shown on the sketch map.

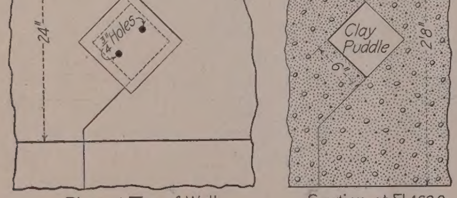
Construction of the embankment was commenced in the spring of 1909 under a contract for earthwork without the concrete superstructure, thus providing for an early completion and an interval for settlement. It is to be noted that the section of embankment from A to B, which was first erected, is to act as an earth dam forming a widewater between the new and the old canal. These embankments, about 80 ft. in height over the greater part, were completed in the fall of 1910. The material used is fine sand without clay and almost free from other substances, and was brought from a near-by hill by train and settled in place by water jets as shown in one of the photographs. The site of the embankment from B to C was cleared of alluvial soil and silt by a hydraulic dredge, but partly on account of insufficiency of equipment, this means of placing material was not used to any great extent in building the embankment.

Construction of the trough from B to C began in December, 1910. This section, which is 3800 ft. long, the total length of trough contemplated under the original plans, was completed in May, 1911, ending the trough just east of the Irondequoit Creek culvert. Meanwhile the prism of the old canal eastward from the end of the trough to Bushnells Basin was enlarged to Barge Canal dimensions, but protection work on the side slopes was unfinished when navigation opened in May, 1911.

A few days later a break occurred in the earth bank, closing navigation for two months. This break was located in the right foreground of the view of the trough, and the vertical wall was erected in closing the gap in the bank. The embankment on the lower slope of the ground consists of the old towpath bank of the Erie Canal enlarged and strengthened, and as the earthwork had been in place for many years, considerable reliance was placed upon its holding qualities. The break revealed serious weakness in the bank, however, and it was decided to protect the sides and bottom of the prism with concrete lining for a length of 1900 ft., beginning at the end of the trough already built and continuing east to Bushnells Basin. An additional trough was also planned just east of the basin over an old culvert smaller than the Irondequoit and with lower embankment. This trough is 900 ft. long. In 1912 and 1913 these additional structures were erected, making a total of 4700 ft. of trough and 1900 ft. of lining.

TROUGH DETAILS

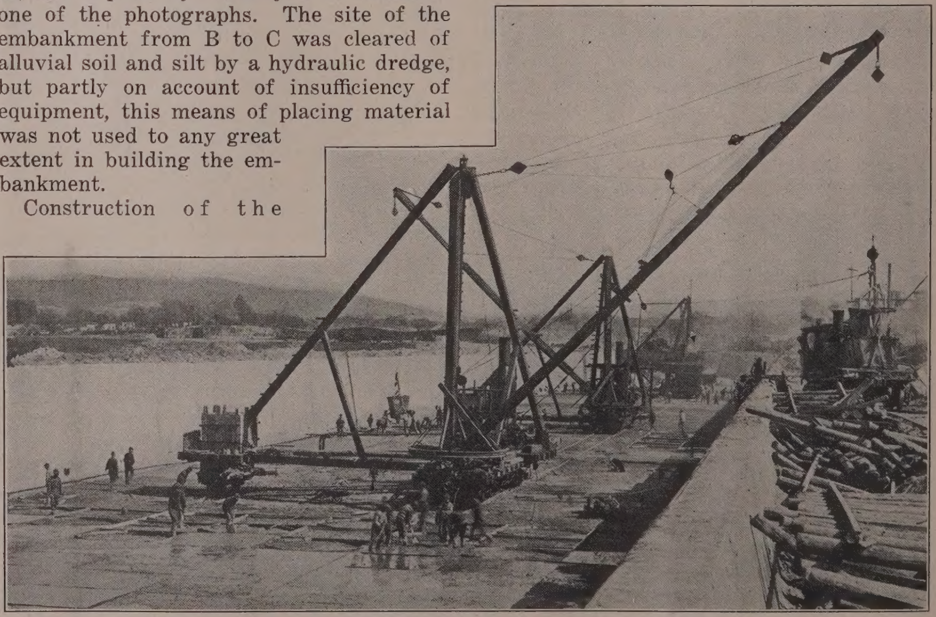
Details of trough and slope lining are shown. The draught is set at 14 ft. to conform with the depth over lock sills under amended plans. The trough walls are built in sections 30 ft. long jointed at the ends as shown. No reinforcement is used in the walls except at the floor connection. The lower course of floor 12 in. thick is built in 30-ft. squares, reinforced with 3/8-in. deformed bars 3 ft. long, spaced 6 in. center to center, and staggered. Upon this is a layer of waterproofing consisting of five thicknesses of single-ply coal-tar felt. Sand to a depth of 6 in. is then spread, followed by a course of concrete 4 in. thick in squares of 10 ft.,



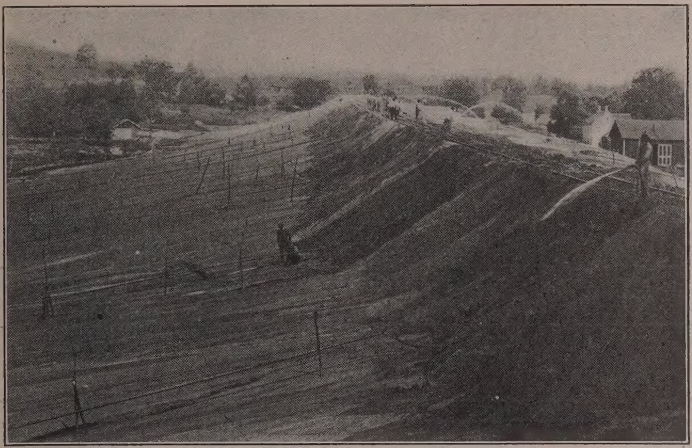
Plan at Top of Wall

Section at El.462.9

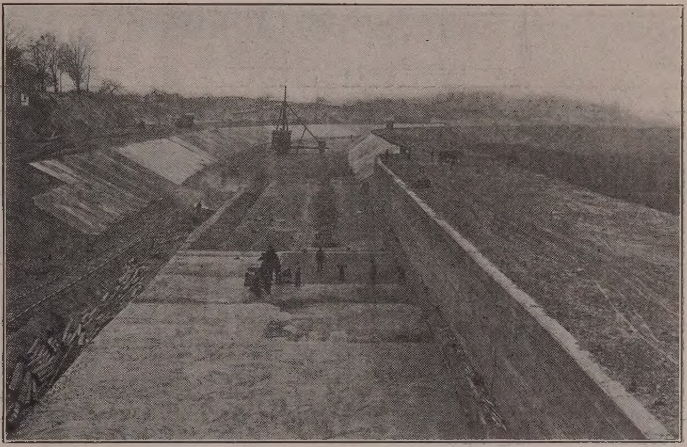
Joints in Trough Walls



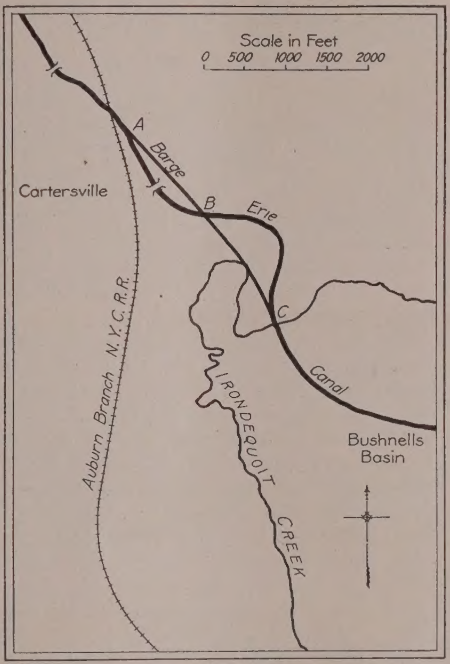
View of Irondequoit Trough Floor in Course of Construction



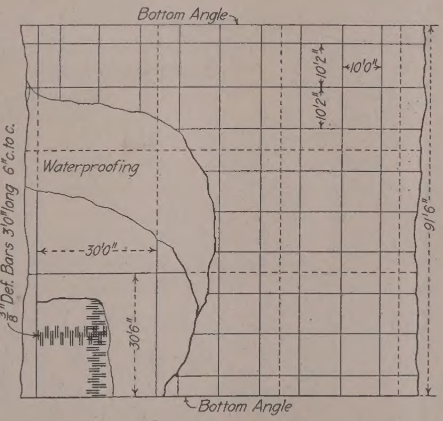
Compacting Embankment with Water Jets



Trough Looking West from Bushnells Basin



Map of Change at Irondequoit Creek



Squares and Reinforcing in Floor

so arranged that the joints are not superimposed on the joints of the lower course.

Concrete was laid throughout winter and in zero weather. This was necessary in order to provide for canal navigation during the open season, as a portion of this construction follows the existing Erie Canal. The walls were erected by means of steel forms, housed in, coke fires being maintained to keep the temperature at about 40 deg. Through such additional precautions as are usual in manipulating concrete during cold weather, the work advanced without delay and satisfactory results were secured. From 800 to 900 cu. yd. were laid per day. The concrete was of gravel mixed 1:2½:5. The trough has developed no structural weakness, and seepage has not been apparent in the 3800-ft. section during the three seasons of navigation since erection. The structure has settled as a monolith 15/100 ft.

BREAK AT IRONDEQUOIT CREEK

The large break shown occurred Sept. 2, 1912, after the trough had been in commission during the navigation season of 1911 and 1912. The mishap occurred over the creek culvert, the creek not appearing in the photograph, as the culvert through which it is flowing is covered with sand. This culvert was erected in the early days of the canal and consisted originally of an arch of 28-ft. span and 2½-ft. depth of arch stone. Within this, at a later date, probably since 1856, an inner arch of 21-ft. span had been built and the space between arches filled with gravel. The contractor had completed lining the arch with 12 in. of concrete and men were building forms at the north end for the purpose of lengthening the culvert. The trough had been constructed above the structure without the earth backing in place behind the side walls, as this backing had to await the lengthening to secure support for the slopes. There were 45 ft. of old embankment between the crown of the outer arch and the floor of the trough, and 35 ft. additional height from the floor of the culvert. Seepage from the trough through this embankment appears to have been absent.

Suddenly, without warning, a slide occurred at the north side over the culvert, carrying down a section of the old bank and exposing the footing courses of the wall and some flooring of the trough for a short distance. The workmen occupied on the lengthening work had barely time to escape, when the embankment dissolved and the trough fell as shown in the photograph.

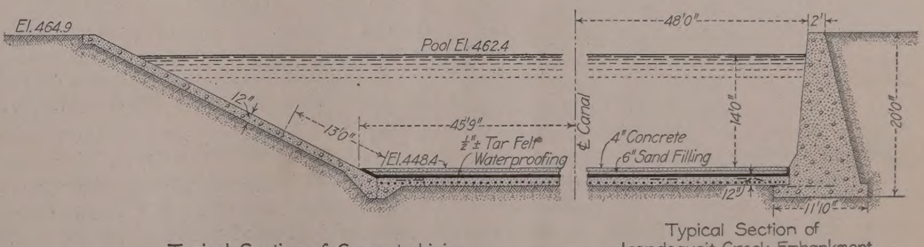
The disaster is attributed to either or both of two causes. There had always been some seepage through the culvert from the old canal percolating through the 45 ft. of embankment. This water in the course of many years must have carried some silty material through the arch and caused cavities and porous places in the earthwork. When the trough was built and filled the greatly increased weight caused settlement in the embankment and opening of joints in the floor and walls. The second cause may have been the consequence of the side walls not having been backed up with earth, affording a tendency to unequal settlement of the prism.

REPAIRS

Temporary repairs were started without delay. The embankment was restored to a sufficient height to support low bents upon which a timber flume 22 ft. wide was built, and navigation was resumed six weeks after the disaster. The flume has been in operation up to the close of navigation Dec. 1, 1913. It has been necessary to post a flagman at each end, as the width has permitted the passage of but one string of boats at a time. It is understood, however, that the flume will be enlarged to 45 ft. in width this winter and continued in service for several seasons.

Plans for permanent reconstruction have meanwhile been carefully studied, and as now tentatively adopted provide, it is believed, for rebuilding the arch culvert, restoration of the embankment, which will be afforded a considerable period for settlement by the continued use of the wooden flume, and finally reconstruction of the concrete trough.

The use of concrete under unusual conditions and along untried lines on so large a scale has given very satisfactory results; and the work is shown to have been performed in a manner creditable alike to the contractors and to the engineers, insuring, so far as good workmanship can, a life of sufficient length to justify the plans upon economic grounds.



Typical Section of Concrete Lining

Typical Section of Irondequoit Creek Embankment

Typical Cross-Sections of Concrete Lining and of Retaining Wall

Sanitary Survey of Boundary Waters between United States and Canada

Report by Experts of International Joint Commission Discusses Extent and Causes of Pollution Considered in Waterways Treaty of Jan. 11, 1909

"THERE is not a municipality using lake water which can be said to possess a safe water supply without treatment." This is the conclusion, based upon an investigation of the pollution of the boundary waters between the United States and Canada, which the board of sanitary experts has reached in its first report, submitted recently to the International Joint Commission. The work of the commission has a twofold object—first, to determine the extent and causes of pollution, and, second, to suggest means whereby pollution, if it exists, may be prevented. It is with the first phase of the question only that the present report deals. Means of abating such nuisances as are found to exist will be discussed in a later document. The purpose of the investigation is to fulfil the obligations of the waterways treaty of Jan. 11, 1909, between the United States and Great Britain, in which it is agreed that the waters therein defined as boundary waters and waters flowing across the boundary shall not be polluted on either side to the injury of health or property on the other. Those in charge of the technical part of the inquiry are Allan J. McLaughlin, surgeon, U. S. Public Health Service; John W. S. McCullough, chief health officer of Ontario; John A. Amyot, professor of hygiene, University of Toronto, and Frederick A. Dallyn, provincial sanitary engineer of Ontario. The sanitary study of streams and lakes along the international boundary began at Lake of the Woods, in Ontario, and terminated at Grand Falls, on the St. John River between New Brunswick and Maine. A summary of the report follows:

The number of sampling points was 1447 and the total number of samples collected, 17,784. Many other samples were taken to show the relation between local situations and municipal water supplies, and to ascertain the character and amount of pollution due to boat traffic. Some float and temperature experiments were made in conjunction with the bacteriological investigation.

BACTERIAL EXAMINATION

The examination was essentially a bacteriological one. Five classes of water were arbitrarily defined, as indicated in the table.

CLASSIFICATION OF GREAT LAKES WATER

Class	B. Coli per 100 cu. cm	Total bacteria per cu. cm agar (10) 37° C
1	Less than 2	Less than 10
2	2 to 10	10 to 25
3	10 to 20	25 to 50
4	20 to 50	50 to 100
5	Over 50	Over 100

Class 1 represents those relatively pure waters found outside the zones of pollution. Class 2 represents a slight pollution of a relatively pure water. At times such a water is undoubtedly unsafe without purification. Class 3 represents considerable pollution, requiring unremitting care in its purification. Class 4 shows serious pollution. In the Great Lakes Basin such a water should not be selected as a raw water for a purification plant; or, if the intake must be placed in such water, sources of pollution should be eliminated or nullified by sewage treatment. Class 5 represents gross pollution—from 50 to 34,000 B. coli per 100 cu. cm.

The maximum bacterial count was used as the index of intermittency of pollution, which is the great menace to water supplies. At the time of inspection extreme runoff due to floods was not encountered. Every municipality in the area investigated on the Great Lakes discharges its sewage untreated into the Lakes, constituting the largest factor in their pollution. The bulk of the work was done on the connecting rivers and the ends of the Lakes.

RAINY LAKE, ONTARIO

Samples examined in Rainy Lake show unusual pollution, probably on account of the presence of construction camps and lumber mills. In general the Rainy River shows serious pollution throughout its length, but in an increased degree below Fort Frances and International Falls to the Lake of the Woods, making this whole river an unsafe source of water supply without very careful purification.

The examination of the waters of Thunder Bay showed that the pollution found there did not reach the international boundary some 35 miles distant. The local situation is, however, an unfortunate one. The general tendency is to spread sewage polluted water along the shores rather than out into the bay. The bulk of the water of Lake Superior is pure, about the only possible source of pollution being from the vessels plying upon it.

LAKE HURON

The examination of samples in the lower end of Lake Huron showed that this water would be practically pure were it not for the pollution due to boat traffic. That portion within a radius of 3 miles from Point Edward Light showed a slight though definite pollution. The sample points near the shore on both Canadian and United States sides gave an average of 15 B. coli per 100 cu. cm. The slight general pollution within this portion of Lake Huron, while due in part to the large summer population and seasonal effect of streams, must be accounted for chiefly by the enormous boat traffic through the middle of this area.

The water of the River St. Clair from its head to Lake St. Clair is unsafe as a source of water supply without careful and unremitting purification. The several cross-sections from St. Clair to Algonac show gross pollution of the river, more marked on the United States than on the Canadian side, owing to the fact that the discharge of sewage is chiefly from the United States side, the Canadian municipalities below Sarnia not being sewered.

The bulk of the eastern portion of Lake St. Clair was shown to be comparatively pure.

DETROIT RIVER

The cross-section where the Detroit River leaves Lake St. Clair showed about the same degree of pollution as the lake in the center of the channel, with increased pollution close to the United States shore. Belle Isle had considerable pollution at the head near both shores. This is enormously increased at the next cross-section, especially at the sample points near the United States shore. The stream above the intake for the Detroit city water supply was found to be an unsafe source of supply without careful treatment. The application of hypochlorite of lime in the quantities or by the method in vogue in Detroit during the investigation is not considered adequate treatment. The several cross-sections from this point to the site of Michigan Central Tunnel showed a marked increase of pollution in the shore samples. The water intakes of Walkerville and Windsor, Ont., are both located in dangerous situations, owing to the discharge of sewage above these intakes and to the pollution due to navigation. Gross pollution over the Michigan Central Railroad Tunnel near the Canadian and United States shores, and a considerable pollution extending across the entire river were found.

The B. coli content per 100 cu. cm has increased in Lake St. Clair water from below 5 to an average of 315 at the head of Fighting Island. Fighting Island divides the river into two channels. There is a great difference in the degree of pollution in these two channels. In the channel between the United States shore and Fighting Island the pollution is enormous.

WESTERN END OF LAKE ERIE UNSAFE

An extensive investigation was made of the area at the mouth of the Detroit River and western end of Lake Erie to Put-in-Bay. The examination indicates the existence of such gross pollution that the water in this part of the lake is unquestionably a very dangerous one, especially to crews and passengers of vessels using water pumped from the region.

There is no point from the lower end of Lake Huron to the islands which separate the western end from the remainder of Lake Erie from which a safe supply of water could be taken for even a portion of the 365 days in a year.

At Port Stanley the evidence indicates that Lake Erie is pure and such pollution as is picked up in the neighborhood of any local source of pollution is confined to that district.

Samples collected at the eastern end of Lake Erie along a line from Point Abino to the United States shore about 12 miles above Buffalo show the water in the eastern end of the lake to be pure, except as it may be influenced by the effect of navigation. Pollution from Buffalo and other sources extended but a short distance beyond the breakwaters, and the water from that point almost to the Canadian shore across the boundary is relatively pure, except as directly influenced by navigation.

DILUTION OF SEWAGE IN NIAGARA RIVER

The first cross-section of the Upper Niagara River showed relatively pure water on the Canadian side and the beginning of noticeable pollution from Buffalo harbor. From the next cross-section to the one below Squaw Island the pollution, though greatly increased in quantity on the United States side, was held to that shore. The pollution on the Canadian side, though of less extent, was likewise confined to its shore. This phenomenon is due to the immense volume and the great velocity of the river, and to the depth of the outlets of the Buffalo sewers. From this point the pollution tended to extend across the entire Tonawanda Channel, and from Rattlesnake Island to the point where it again joins the main river the whole channel was shown to be grossly polluted. The use of this water as a public supply, even with the stringent purification, is attended with considerable risk.

The Niagara River at Lewiston receives the water from the Great George Rapids and the Niagara Falls. The mixing of the sewage effected by the falls and rapids with the river water is probably the most complete possible. The samples examined showed that from this point to the mouth of the river the water was uniformly polluted from shore to shore and that the use of water from this section of the river as a public water supply without the most careful and exacting purification should not be considered.

The situation at the mouth of the Niagara River is different from that of any other of the waters under investigation. At the mouth of the Detroit River the discharge is into an inclosed end of the lake, where it is lagooned and drifted from point to point for a considerable time before it can get into the lake itself. At Niagara, the pollution is discharged into a portion of the lake where conditions are such that the drift may take place north, east or west. Several limits of this polluted area were determined with a considerable degree of accuracy. A striking phenomenon exhibited over this area was that very little diminution in pollution occurred until the limiting boundaries of the area were reached. That is, if at the mouth of the river pollution was such as would show 1000 B. coli per 100 cu. cm, the pollution 10 miles from shore, wind conditions being favorable, would show practically the same degree of pollution. The menace in this area is almost entirely directed at the present time toward navigation between Buffalo and Toronto.

INFLUENCE OF SUMMER RESIDENTS ON THE ST. LAWRENCE RIVER

The work on lower Lake Ontario and on the St. Lawrence River was performed at two different seasons by different laboratories. In the season before navigation commenced Lake Ontario water was practically sterile; in August there was minor pollution in the lake. The difference in the findings emphasizes the effect of boat traffic and summer residence pollution.

Below Brockville the major pollution remains near the banks of the river. Midstream samples showed very little pollution in the early work before navigation. The later work in August showed a very general serious pollution, due probably to summer resort population on the river and to boat traffic. The conditions from here on to Cornwall are very bad in the summer months. Unquestionably the water at Brockville and from there on should not be used as a water supply without adequate purification.

The St. John River forms the international boundary between Canada and the United States for about 70 miles of its course. The direct sewage pollution from Edmundston to Grand Falls is at present slight. There are seven potato starch factories which have some effect upon pollution.

An average for this portion of the river at this season might be tentatively expressed as follows: Average number of B. coli per 100 cu. cm, 125; average number bacteria per cubic centimeter on agar at 37 deg. C., 250.

A remarkable relation between potato starch factories and increase in B. coli was found. The character of pollution from starch factories resembles that of so-called rural pollution, the washings of manured fields, and is largely of animal origin. While it is not so dangerous as city sewage in the transmission of typhoid fever, it is nevertheless a dangerous addition in drinking water. The amount of pollution contributed is of the greatest importance because it has a direct bearing on the distance required for the stream to purify this addition to its burden of pollution and reach what may be considered its normal condition.

The total amount of pollution contributed at any of the points mentioned is relatively small, and within a short distance the number of B. coli per 100 cu. cm drops to what may be considered the average pollution of the river. In this large stream, with the relatively small amount of pollution after mixture has been effected, marked improvement is manifest within a few miles. For instance, from the point of maximum pollution about 4 miles below Van Buren, a marked improvement is evident within 4 miles, the average number of B. coli per 100 cu. cm dropping from 725 to 57.

CONCLUSIONS

In certain localities on the Great Lakes and in all their connecting waterways dangerous sewage pollution was shown to exist, but the great bulk of the Great Lakes water remains in its pristine purity.

The colon bacillus is practically never normally present in unpolluted waters, and the normal total bacterial count of the Great Lakes waters is below 10 per cubic centimeter on nutrient agar. This is clearly shown by the results of examination of samples collected in Thunder Bay, in Whitefish Bay, in Lake Huron, in Lake St. Clair, in Lake Erie at Abino Point section, and in cross-sections of Lake Ontario at both ends.

The boundaries of the zone of pollution along the shores or at the mouths of rivers were constantly changing, due to the currents which are themselves dependent upon the direction and velocity of the wind. In two situations, namely, at the mouths of the Detroit and Niagara Rivers, serious pollution extends normally over 10 miles into the lake receiving the discharge. At times it may travel much farther. It was shown to travel in Lake Ontario on occasion 16 miles, and in Lake Erie, 18 miles.

The position of intake and the pollution existing in the vicinity of municipal water supplies are such that there is not a municipality using lake water which can be said to possess a safe water supply without treatment. In spite of these facts until very recently the use of untreated water was the rule. The conditions responsible for the disgraceful record of water-borne typhoid in these cities are: Unrestricted discharge of sewage by municipalities and vessels; failure to purify polluted water, and inefficiency in the purification. In certain localities the pollution is so great as to impose an unreasonable burden upon any known method of water purification, and where intakes are located in such localities some method of eliminating or reducing the pollution, whether from boats or municipalities, is absolutely necessary. It is difficult for some officials to understand, without a severe lesson, that it is not sufficient to have a water supply that is safe for 360 or 361 days in the year. There was no evidence of serious pollution of the water supply of the city of Erie from 1909 to December, 1910, yet the appalling experience of January and February, 1911, showed that pollution could take place under certain weather conditions.

Untreated water supplies are in many instances delivered to the consumer as safe. No water should be classed as safe and furnished as such which is not shown to be safe by daily bacteriologic examination. Opinions based upon a few widely scattered bacteriologic examinations of samples of municipal water supplies collected at random have really very little value even though the tests appear to indicate good water. The public is apt to base its opinion of a water supply upon such tests. This is a dangerous error. Any report upon a water supply is incomplete without a comprehensive sanitary survey. The possibility of a serious pollution even as an exceptional occurrence would be disclosed by this survery.

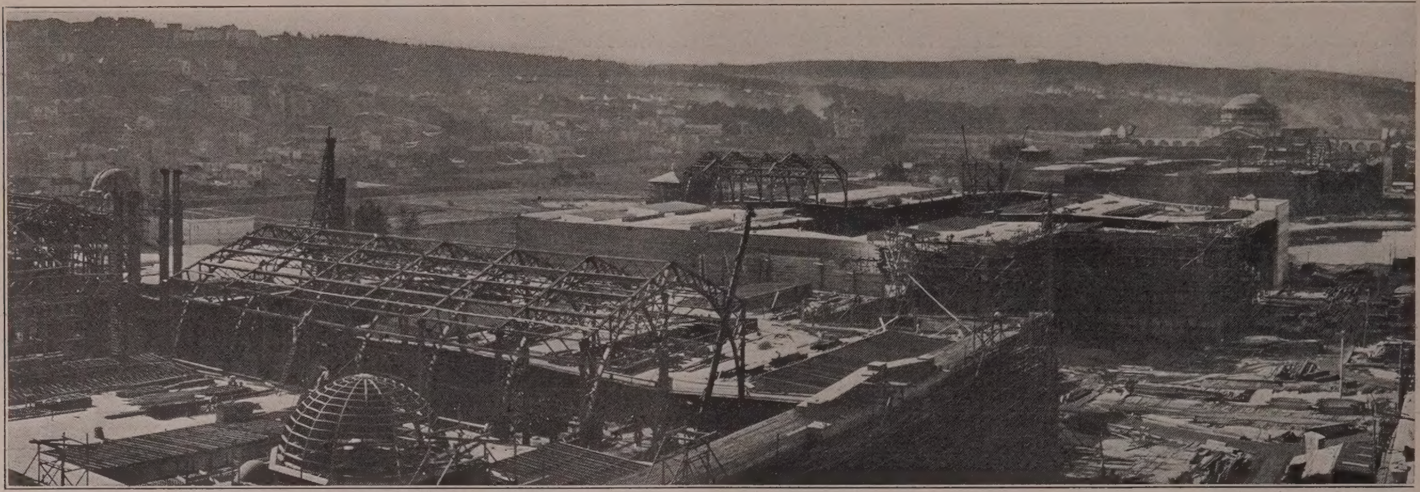
Information collected during this investigation shows that for lack of bacteriologic control satisfactory efficiency is not being obtained by the purification methods adopted by many of the municipalities attempting to protect themselves against the consequences of polluted water supplies.

Chicago Building Commissioner's Report for 1913

REDUCTION of the limit in height of buildings in the downtown district of Chicago from 260 to 200 ft. by the ordinance of 1911 has had a deterrent effect in the erection of new buildings during 1913 in that section, according to the annual report of the building commissioner, Mr. H. F. Ericsson. Many of the larger buildings still in course of erection are structures for which permits were issued previous to restrictions imposed. The advantage lost downtown has been made up in residences, flats and apartment buildings, so that the total estimated cost of structures for the year is not far different from that in 1912. For 1913 the estimated cost of the 76 office buildings was $2,706,400, while in 1912 it was $4,571,000 for 49 similar buildings. The 5034 flats and apartments cost on an average of $7860 each, and the 3519 residences, $2600 each. The total frontage amounts to 60.3 miles.

Inspections of theaters resulted in the condemnation of nine buildings, five were closed permanently and four brought to compliance with ordinances passed in July, 1913. Two of the latter required remodeling from the ground up. Of 8300 buildings covered at the annual inspection, 6225 were found violating the ordinance. The commissioner is of the opinion the orders issued will be found obeyed to such an extent that few violations will be encountered this year. The total number of inspections of all kinds was 152,223, an average of 282 by each of the 45 inspectors.

Plans examined by the architectural and engineering bureau numbered 2030, while 48 theater roofs were tested, 68 reinforced-concrete floor tests conducted and 918 buildings were placarded with cards giving safe loadings. Three engineers make up the force, but a fourth man is recommended.



Panorama of Part of the Main Exhibit Section of the Panama-Pacific International

Damages to Contractors by Delays of Other Party

Binding Effect of Contract Terms Even If Provisions Are Onesided

By **WILLIAM B. KING**

Of the Bar of the Court of Claims, Washington, D. C.

THE Court of Claims on Jan. 12 handed down an opinion in the case of the New Jersey Foundry & Machine Company vs. United States, holding that the courts are bound to enforce provisions contained in contracts signed by both parties, even if they are of an extremely one-sided character. The contract in question was for the construction of a marine railway at the naval station in Key West. Certain dredging was required before the contract work could be done. The government undertook to do the dredging itself. The contractor for the marine railway was delayed in going on with his work because the government was guilty of great and unreasonable delay, it was alleged, in doing the dredging. This delay caused by the government resulted in a loss to the New Jersey Foundry & Machine Company, the contractor for building the marine railway.

This contractor filed a suit in the Court of Claims for the damages sustained on this account and the United States showed that the contract contained the provision that "the government will assume no responsibility for delays due to dredging." The provision was entirely onesided, for the contractor for the marine railway was bound to proceed with diligence in executing his contract and yet, by this provision, was not to hold the government responsible for losses caused by delay due to the government's failure to do its preliminary work in time.

CONTRACT TERMS BINDING

The Court of Claims in deciding the case acknowledged that it was the duty of the government to do the dredging, but held that the contract terms must govern in regard to its responsibility for damages for its delays in doing the work. The court said that the contract was a waiver by the contractor of any right to recover damages for such delays by the government. It was consequently decided that there could be no recovery, although the damages were caused by the act of the government.

In support of this conclusion the Court of Claims referred to an earlier decision on a claim for work upon the United States Post Office building at Washington, in which it was explicitly declared that no claim should be allowed to the contractor for damages for any delay caused by the other party. In that case the court said:

"In respect to the right to recover damages for delays the contract is purely unilateral and is confined to such damages as might be caused by the contractor alone, and for the delays caused by the defendants there can be no recovery."

This case enforces upon contractors two important things—the first, that they are bound by the provisions of contracts which they may sign, however unjust and onesided these provisions may be; the second, that it is of great importance to contractors that there should be some reform in the framing of contracts for engineering and building work so that the courts will not find it necessary to enforce so plain an injustice.

Progress on Panama-Pacific Exposition Buildings

Panoramic View Shows Condition of Some of the Largest Framed Wooden Buildings Ever Constructed

THE present condition of many of the buildings under construction for the Panama-Pacific Exposition is indicated by a panoramic photograph taken Jan. 1. It shows a remarkable group of the largest framed wooden buildings that have probably ever been constructed. These have been carefully designed and proportioned to develop the efficiency of the magnificent timber available on the Pacific Coast for structures that nearly everywhere else would require steel frameworks. A number of them are in a stage that exhibits the uncovered skeletons and shows their dimensions and the character of trusses and arches soon to be inclosed by roofs and walls.

On the left hand are seen the hills of San Francisco, in the center the hills of the Presidio reservation, and on the right is San Francisco harbor. In the left foreground is the 414x541-ft. Palace of Varied Industries. In the right foreground is the 451x579-ft. Palace of Mines and Metallurgy. Next to Mines and Metallurgy, facing the harbor, is the partly erected 579x614-ft. Palace of Transportation. The next structure facing the water is the 424x579-ft. Palace of Food Products.

The second building from the left, and the farthest from the bay, is the 475x552-ft. Palace of Manufactures. Next is the 475x585-ft. Palace of Liberal Arts, and beyond is the 394x526-ft. Palace of Education, with a dome 160 ft. high.

When completed some of the domes and towers will rise to heights of 160, 250, 370 and 430 ft.

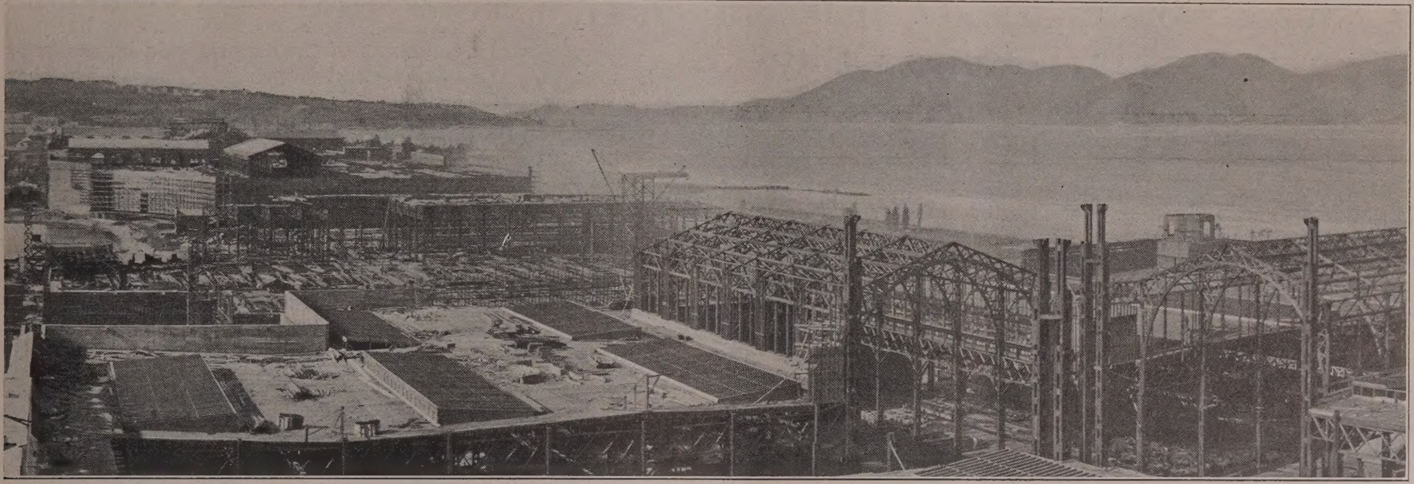
Water-Power Conservation in Massachusetts

Commission Recommends That the Legislature Provide for Complete Investigation of Water Resources of State and Outlines Past and Prospective Work

THE Massachusetts Commission on Water-Power Conservation, created by Chapter 129 of the Resolves of 1913, has filed a preliminary report with the Legislature, recommending that the investigations undertaken be continued and commenting at some length upon the status of water power in the commonwealth and the need of co-ordinating data upon this subject. The board consists of Hon. William S. McNary, chairman; Hon. Forrest E. Barker; and ex-officio, the attorney-general of the state, Hon. James M. Swift, being the incumbent at the time the commission was created. The chairman is also chairman of the Massachusetts Harbor and Land Commission and the second member of the board is chairman of the Massachusetts Gas and Electric Light Commission, the secretary being Mr. James C. White, of Boston, Mass.

PURPOSE OF COMMISSION

The special purpose of the commission was to investigate and report what legislation, if any, is expedient or advisable to better conserve the waters and provide for the equalization and utilization of their flow in the streams of the state. Public hearings were held in Springfield, Greenfield, Pittsfield and Boston, and much interest in the subject was manifested. Everywhere it was regarded as one of great importance to the manufacturing, agricultural and community interests of the State. In its report, which will shortly be printed, the commission points out that water conservation as now understood has hitherto been given virtually no consideration in the legislation of the state. Even the authority given to certain officers who are charged with the supervision of dams and similar structures entirely lacks recognition of the conservation principle. This authority looks chiefly to securing suffi-



Exposition as Seen from the Roof of the Palace of Machinery on January 1, 1914

cient strength in the structures allowed to hold the waters impounded, but gives no attention to the equally important subject of the proper method of developing and regulating the flow.

Although the statutes of recent years contain numerous instances of grants to persons and corporations to take and use water, the state is still handling this great natural resource in the main in accordance with the so-called "Mill Act" of Colonial times, which still continues the riparian owner as the chief factor in the field, with no regard to broader interests. Due to this vagueness of governmental supervision and the difficulties incident to the strict application of the existing law, many riparian owners have assumed the right to increase and otherwise alter the obstructions placed in the rivers with too little regard to their original grants. Certain practices of municipalities in securing water supplies have also given rise to confusion. Protests have reached the commission that the larger municipalities, by legislative permission, are seizing water courses in towns too weak successfully to resist them. The State Board of Health is required to advise or recommend on all such petitions to the Legislature, but its work is confined mainly to sanitary considerations or to the general availability of the supply, and the piecemeal development of water supply systems continues.

EXISTING DATA INADEQUATE

The commission finds a great lack of reliable information regarding the ponds and lakes of the state, whose area has been established so far by only the roughest calculation. The actual water power being developed or the potential power is unknown to the board, and even the number, size and extent of dams has never been compiled so as to be available for the study of the conservation problem. No adequate surveys or studies of the state's water resources have been made, and none is likely within the time which the urgency of the subject requires, unless special provision is made. The board made a special study of the tax assessment books in various communities to secure the names and addresses of owners and users of water power privileges, and information was also sought directly from these persons. By this means, supplemented by field work, a complete tabulation could be built up. Owing to the great number of such persons and the amount of detail involved, it has been impossible to complete the task; but a substantial part of the western end of the state has been covered, and a tabular statement of this information is to be published with the board's report. Incomplete as these data are, they vividly illustrate the great value of the water used and the great loss now suffered through the lack of equalization and proper utilization of natural resources.

For information as to streams, recourse was had to the work of stream measurement now being conducted under a joint appropriation of the State and Federal Governments, but due apparently to the small appropriation, this work is far from completion. Extracts from this investigation and data gathered by the board upon hydroelectric developments in New England are to be printed, and the commission has brought the data contained in the report of the United States Bureau of Corporations on Water Power Developments (printed in 1912) down to date so far as it refers to New England. By the new investigations the total developed and undeveloped water power in Massachusetts has been materially increased.

DEFINITE POLICY NEEDED

Massachusetts stands next to Maine in New England in the amount of water power actually developed, and probably also in the total undeveloped power. Manufacturers located on water courses or within reasonable reach of hydroelectric transmission lines are becoming vitally interested in the subject and desire to ascertain the policy of the state respecting it. The commission points out that this policy can only be safely determined on the basis of adequate investigation of a more comprehensive character than heretofore has obtained. The Harbor and Land Commission, State Board of Health, United States Geological Survey and other bodies possess data which should be assembled. In view of the limited amount of the appropriation for its use, the commission assumes that the Legislature did not intend to authorize so broad an inquiry as now seems imperative, and neither did it seem expedient to use any portion of the appropriation to inaugurate an engineering inquiry which could have no practical results and value except as a part of a more extended investigation.

The board states that the prosperity of Massachusetts is materially dependent upon manufacturing, and points out that the steady advance in the cost of coal, both present and prospective, emphasizes the importance of utilizing to its highest efficiency every natural source of power. From the census of 1909 it appeared that of the 1,175,071 hp used in manufacturing in the state, 185,996 hp are credited to waterwheels, and there is reason to believe that several times this amount of water power is annually wasted. If this can be economically conserved, it will add immeasurably to the wealth of the state and its citizens. A satisfactory choice as to the method of conservation to be employed, whether by the state or by private interests, can only be made when more is known as to the water resources themselves.

The commission recommends that the Legislature provide a complete investigation of all the water power resources of the state, to secure the proper basis for a report upon utilization. A large part of the present appropriation remains unexpended, and the board recommends that its authority to continue the investigation be extended until further action of the Legislature upon the report. Two resolves are presented, one extending the authority of the board prior to further action of the present Legislature, and the other providing for a comprehensive investigation by the commission with the duty of reporting its findings in January, 1915, to the Legislature then in session.

Minneapolis Municipal Depot

SEVERAL plans have been prepared for a municipal railway terminal at Minneapolis, which all railroads entering the city would use. Three separate stations are now in use. Three years ago the state legislature passed a law authorizing cities of the first class, of which Minneapolis is the only one, to build union stations and to force all railroads to use it. A year ago the law was amended to cover a defect and last November the City Council ordered the city engineer to prepare plans. By the law the city can condemn property, relocate depots, design and force railways to use the municipal terminal at a rental charge which will pay interest on the bonds and create a sinking fund. The city will submit the plan to the Railway Warehouse Commission, from which body the railroads may appeal to the courts in case of disagreement. The nearly completed union station for the Chicago & Northwestern Railway Company and the Hill roads may or may not be utilized in the new scheme.

Success of Engineer-Manager Plan in Small Kansas City

Uniform Reduction in Administration Expense Result of Adoption of Commission Form of Government

EIGHT months of commission government with an engineer as executive, in Abilene, Kansas, a city of 5000, have witnessed a systematization of municipal work shown in new activities and substantial reductions in the unit costs of administering all the existing departments. This statement was made by Kenyon Riddle, city engineer of Abilene, in an address before the members of the Kansas Engineering Society at its recent convention at Lawrence. An abstract of the paper follows.

NECESSARY QUALIFICATIONS FOR A CITY MANAGER

The foundation of this method of municipal government has been a board of directors and a principal head or manager, through whom this board can direct innumerable subordinate officials and employees. Preferably, the manager should be without extensive interests in the town or city which he serves. This makes it more possible for him to give impartial views in matters concerning employment of labor and purchasing of material. His preparation should consist in a thorough education along the lines of general engineering rather than a knowledge of a few special branches. This will make it possible for him to advise and check up, in a general way, every act of the engineering department. He should be economical, having an understanding of values and ability to estimate all classes of construction and maintenance work, he should be able to establish systems of record-keeping and cost data and should have a general conception of business methods and finances and, in addition, should understand the city's sanitary and social conditions, most important factors in public welfare, where inefficiency causes every imaginable trouble. Here is involved the street cleaning and disposal, water system supply and sanitary sewer system, drainage system, the working and living quarters of every class of people, the transportation facilities and numerous other items. It is not at all difficult to see that the great majority of the city's affairs are of an engineering nature and should be managed by an engineer.

SMALL TOWN CONDITIONS

A general knowledge of all of the above particulars is not too much to expect of a city manager. However, since men have not prepared themselves for this particular situation, it may be well to try the new system of control in smaller towns, for in these places some of the qualifications can be stricken out entirely and others are of much less importance. On the other hand, in the larger cities the different departments are more complete in themselves and would require less direct supervision and advice from the manager.

The principal dissipation of municipal funds comes from lack of knowledge, most often conspicuous in the engineering department, and since the great majority of the city's business is of an engineering nature this makes up the greatest waste. This particular argument best fits the town which is believed too small to feel the necessity of employing an engineer the year around. These are the places where a lack of knowledge makes up the principal reason for receiving about three-fourths value on each dollar spent in taxes. The permanent improvements and systems in such places are the nuclei for possible larger systems; therefore, they should be carefully planned so as to meet future conditions. They should also be accurately recorded.

If a town or city had some means of figuring the money wasted in prospecting for lost underground systems, in the improvements buried and never found, in systems that are built with no idea of future growth and that have to be abandoned years before they are worn out, in the grading and re-grading of streets, in sinking hundreds of dollars into permanent culverts and waterways built with no idea of future drainage and requiring removal when pavement is laid, it would not be difficult to prove the economy of city planning.

No doubt the employment of an engineer as manager by the smaller cities will at first blush seem too expensive; however, the thoroughness of record keeping which is made possible by the step more than obviates this objection. There are, moreover, several ways in which an income to the city's general fund can be realized by the newly created office. No matter how small the town, all sewer work, plumbing, wiring, water mains and services, meters, etc., should be inspected, and the small cost for doing this should be charged to the property owner. Then there will be the ordinary expenses of surveying lot lines and giving grades for buildings and sidewalks; these also should be charged to the property owner and the receipts turned into the general fund. Further, there will be the usual engineering for sewer and water extensions, curbs and pavements. And, finally, if the manager has charge of the street work, the street commissioner's salary may be added. The aggregate of these different amounts, if the town were doing its share of improvement work, would be sufficient to employ a competent engineer, without extra draft on the municipal funds.

SAVING UNDER ENGINEER-MANAGER

To prove that this is not all theory the improvements and the indicated savings for Abilene for the eight months through which the engineer-manager has been employed are given. The following items represent the extent of the municipal work: Street improvements, $80,000; installation of ornamental street light system, consisting of five-light and single-light concrete standards, city's share, $1,200, light company's share, $6,800; water-works improvements, consisting of general overhauling and new pump at plant, and booster pump, $5,275; water main extension, $2,910; sewer extensions, $2,136; a total of $98,321.

The city has a contract with the light company to pay $3,000 a year for three hundred 40-watt lamps; about one-half of these are burned every night in the week and the balance are burned about one-half the time.

A comparison of unit costs, past and present, of the several small sewer and water extensions is shown in Table 1. In executing the recent work the city has purchased all of the material and let the labor to the lowest responsible bidder. All other conditions are practically identical—the cost of labor and material, depth of trenches, quality of soil, etc.

TABLE 1—COMPARATIVE UNIT COSTS, FOR OLD AND NEW METHODS OF GOVERNMENT, OF WATER AND SEWER EXTENSIONS IN ABILENE

	Unit cost	
	Past	Present
Excavating and refilling trenches averaging 8 ft. deep, per linear foot	40.8 cents	25 cents
Furnishing and laying 6-in. vitrified sewer pipe, per linear foot	19.5 cents	15 cents
Furnishing material and building flushtanks, each.........	$66.00	$51.80
Furnishing materials and building manholes, each..........	$40.80	$23.00

The total saving, by items, is given in Table 2.

In the waterworks department the difference between the unit costs under the old and new systems is about 8 cents per linear feet. For the 5010 ft. laid this year the saving would be $400.80.

The cost of cleaning the pavement and disposing was cut from an average of 50 cents per 1000 sq. yd. to 36.3 cents per 1000 sq. yd. Therefore, on the total area of 2,315,697 sq. yd. covered in order to keep 92,000 sq. yd. clean for six months there was a saving of $317.25. Under the new system the street commissioner turns in a progress and cost report.

Without giving other figures Mr. Riddle states that in every department there has been a saving. In addition, new municipal activities have been initiated. The dragging of dirt roads formerly was considered too expensive. No one had any idea how many miles of dirt streets the town had which could be considered as arteries of traffic nor how much a mile the dragging should cost. In order to prove that all of the more important streets could be dragged at a nominal cost two districts were laid out and worked. For each a log-sheet was made, showing the streets to be covered, the number of treatments for each and the number of miles traveled. One district has 16½ miles and the other 19 miles; when the streets need dragging two outfits are employed, each of which is paid $6 for following out the course. During the past eight months—of course, some of these months were quite dry—the dragging has cost $51.

TABLE 2—ITEMIZED STATEMENT OF SAVING FOR WATER AND SEWER EXTENSIONS

4721 linear feet of excavating and refilling	$745.92
4721 linear feet of furnishing and laying..	212.44
3 flushtanks	42.60
4 manholes	71.20
Total amount saved.......................	$1,072.16

As a conclusion of the indications of economy, it is stated that the tax in Abilene is 64 cents on each $100 valuation. Besides the $1,790 which has been saved, as itemized here, the city has a complete set of records of all underground work and of every survey made.

In order that all important work shall be authorized by the commissioners as a body, with a clear understanding on their part, a report of the coming week's work is prepared by the manager, together with a preliminary estimate of the cost and an account of the benefits derived, and is presented at the meeting of the board. After the work is discussed the commissioners order what they deem necessary. The manager then takes charge and at the next meeting of the board reports the progress, or, if the work is completed, he submits the final estimate. With this procedure the commissioners are thoroughly acquainted with all of the city's affairs.

With all of the principles which have been discussed here, concludes Mr. Riddle, and with the conclusive evidence of efficiency which has been cited as attained by the businesslike methods which are possible in the engineer-manager plan, there seems to be absolutely no question that it is the ideal form of public control, particularly for municipalities, and probably, while in its experimental state, most applicable to the smaller towns.

Chicago Railway-Terminal Situation

Abstract of Progress Report by Bion J. Arnold and Walter J. Fisher to the Citizens' Terminal-Plan Committee of Chicago

RESULTS obtained from the hearings in Chicago last December on the railway-terminal problem are summed up in a report of Messrs. Bion J. Arnold and Walter J. Fisher, submitted to the Citizens' Terminal Plan Committee. No ordinance permitting a union station was accepted and the railroads finally requested a postponement, stating that the freight and passenger terminal problems are inseparately connected and that both were so difficult and intricate as to require further study.

According to the report, the problems as the railroads see them are not the most important and difficult issues involved. In the judgment of Mr. Arnold and Mr. Fisher they are:

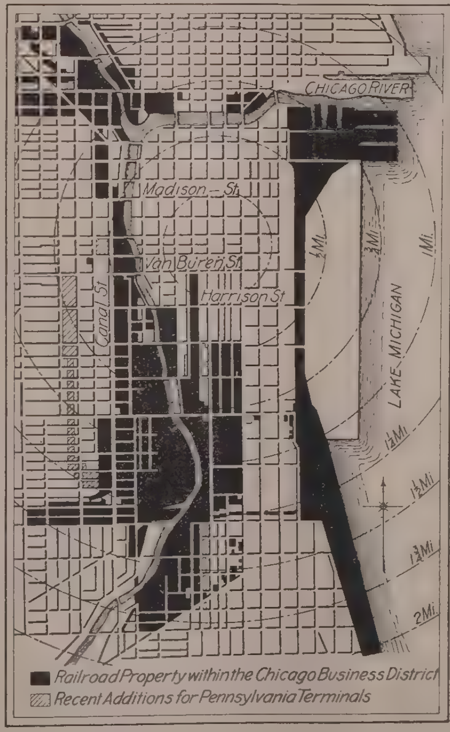
First, the opportunity for adopting and taking the first important steps in a comprehensive treatment of the railroad-terminal problem which is offered by this application of these important railroads for the consent of the city to the establishment of new passenger and freight facilities, and second, the importance of seeing that the provisions of any ordinance now to be passed are right in themselves and are not in conflict with a correct solution of the terminal situation as a whole.

PRESENT STATUS

The present situation and the proceedings before the council committee, the report says, can fairly be summarized by saying that as yet practically no advantage has been taken of this great opportunity to make substantial progress toward the establishment and execution of a comprehensive plan for the solution of the railroad-terminal problem—the most imperative and important problem relating to the future physical development of Chicago; while, upon the other hand, real progress has been made in revising some of the specific provisions of the pending ordinances and in reducing the obstacles which these ordinances as originally drafted threatened to place in the way of a correct solution of the terminal problem as a whole. These ordinances, as introduced by the railroads, contained no provision whatever upon points of the greatest importance to the public interest, and many of the provisions they did contain called for extensive and careful revision. This revision was in progress when the railroads asked for a postponement of further consideration. Provisions have been inserted for viaducts and other approaches upon important West Side streets and for widening Canal Street and its connection with the North Side by viaduct and bridge; and the public interests have been more effectively safeguarded in many places, but, as Mayor Harrison has said, these are all things either made necessary by what the railroads have done or wish to do, or clearly beneficial to them or their property. The real character and effect of the freight-terminal ordinance, as introduced by the Pennsylvania Railroad, had been made so apparent that its definite rejection by the council committee was assured, and Mayor Harrison (comparing the proposed freight station with the new Chicago & Northwestern terminal) had said of it that "a City Council and a Mayor that would pass an ordinance that would permit a monstrosity of that sort to be put up in Chicago would be worthy of being lynched."

Messrs. Arnold and Fisher think it may be fairly stated to have been established before the council committee as correct public policy that if any new freight terminal is to be permitted north of Twelfth Street and east of Halsted Street, it can only be done if the tracks leading to it are depressed below the level of the streets and are covered at the time of construction. Provisions for an ordinance embodying this principle were drafted and recommended by Mr. Wallace and Mr. Arnold, and had received the tentative approval of the subcommittee. The establishment of this principle is the one big step toward a correct general policy which has been pretty definitely determined upon as a result of the consideration of the pending ordinances.

Unfortunately, according to the report, there has not yet been taken the more important step of reducing as rapidly as possible the present railroad-terminal uses of the great area now withdrawn from general commercial development within the territory east of Halsted and north of Twelfth Street, which is needed and should be opened for the expansion of the central business district, and of confining future railroad terminals within that district to the Illinois Central tracks east of Michigan avenue and to the naturally depressed area between Canal Street and the south branch of the Chicago River. The co-operative plan recently established at Clearing should be a beginning of the policy of excluding from the center of the city the handling of freight (both carload and less than carload lots) which is not to be used within that center and which now needlessly adds to its congestion and to the expense of both railroads and shipper.


CHICAGO RIVER
Madison St
Van Buren St
Harrison St
Canal St
LAKE MICHIGAN
½ Mi
¾ Mi
1 Mi
1¼ Mi
1½ Mi
1¾ Mi
2 Mi
■ Railroad Property within the Chicago Business District
▨ Recent Additions for Pennsylvania Terminals

Railroad Property in Chicago

Only by the substantial reduction of the area occupied by passenger and freight terminals in the central business district and the reconstruction of the remaining terminals along right lines can that district normally and naturally expand as it should toward the south and west. The location of the union passenger station between Adams and Jackson Streets on Canal Street will not only add to existing congestion, the report says, but the railroads themselves are claiming that their facilities in this location will be so cramped that they cannot postpone the immediate use of two tracks which they were asked to depress and cover so as to permit a 20-ft. widening of the surface of Canal Street.

ROOM FOR EXPANSION

It is hoped that the postponement of these ordinances will lead to a clearer appreciation, both by the public and the railroads, of the significance of the following statement of President Earling of the Chicago, Milwaukee & St. Paul Railway Company:

"It will hardly be worth while to erect an expensive station such as this is going to be, and spend—I do not know how much, $30,000,000 or $35,000,000 or $40,000,000, whatever it may be—and then find that we have not track room enough; to find in a very few years that there was not track room enough for the business of the roads. It would be deplorable, and I should feel that we were subject to the criticism of everybody that came after us."

If more mature consideration should lead to the withdrawal of the union passenger station at least as far south as Harrison Street, where there is more room for future expansion, as pointed out in Mr. Arnold's report abstracted in the Engineering Record of Nov. 29, 1913, this would seem to be to the advantage of the railroads as well as of the city. With such a withdrawal it might be able to approach with fairness the competing railroad whose president discussed before the council committee the conditions affecting the southward withdrawal of the present terminal of the Lake Shore & Michigan Southern Railroad. Out of this might easily develop a general movement of incalculable advantage to the city of Chicago.

Real progress was made by the city authorities in a clearer appreciation of the necessity and practicability of straightening the south branch of the Chicago River. Both Mayor Harrison and the council committee seem to realize that now is the time to secure an agreement from the union station railroads for this river straightening.

The report deplores the fact that the great question of solving the general railroad terminal situation through the interchange of railroad tracks and properties, the gradual withdrawal of unnecessary terminals from the center of the city, and the inauguration of through-routing, especially for suburban service, has received no adequate attention from the council committee or the city administration. The lessons so slowly and so expensively learned with respect to through-routing on our street and elevated railroads are still unlearned with respect to the suburban and through traffic of the railroads which are now operated by steam. Many of the city officials are still deluded by the belief that obstacles in the way of the free movement of transportation within and through the city are somehow to the advantage of Chicago. They do not yet see that these obstacles and the expense, discomfort and delay they entail upon the people of Greater Chicago are a needless burden imposed upon the people as a whole for the benefit of the comparatively small class who own property or do business at the points of congestion. They are just beginning to see that the only way in which the central business district can naturally and healthfully expand, and in which outlying centers of business and of population can develop, is by making the means of transportation through the central district and between the outlying centers convenient, speedy and inexpensive; that such transportation enlarges the distances from their homes within which industrial workers can profitably and comfortably find employment; and that the steam railroads and their urban and suburban rights-of-way have here great possibilities of usefulness and profit. It is the attempt to provide in one terminal for suburban service and for long-distance traffic that is building at enormous cost huge monumental structures not needed for and not desired by suburban passengers, who would be far better provided for by conveniences of leaving and boarding trains at appropriate intervals along through-routed lines. Here are possibilities of efficiency and economy which are interesting a few practical and influential railroad men, and which are being realized in other cities whose experiences and achievements in this direction are but little known to Chicago.

Dayton Flood-Prevention Plans

Report by D. W. Mead, J. W. Alvord and S. M. Woodward on Scheme Proposed by Morgan Engineering Company

FOLLOWING the preparation by the Morgan Engineering Company of tentative plans for the protection of the Miami Valley from floods, Messrs. D. W. Mead, J. W. Alvord and S. M. Woodward were appointed a consulting board to pass on the plans (which were described in the Engineering Record of July 12, 1913, page 38). They have held several meetings, considered the scheme proposed, suggested certain studies, which have since been made and reviewed, and, under date of Jan. 17, 1914, have rendered a report to the Dayton Flood Prevention Committee. This is not a final report, but covers the work to date of presentation. The document, omitting introductory paragraphs, is as follows:

THE REPORT

Flood protection must usually consist of:

1. Channel improvement, including levees, to provide for the safe passage of floods; or,
2. Reservoirs for the partial or entire retention or delay of flood waters until they can be safely and slowly released; or,
3. Such combination of channel improvements and flood reservoirs as the local conditions may render most practicable.

These methods of flood protection are not new, are based on thoroughly established engineering precedent, and are not solely a matter of theory.

CHANNEL IMPROVEMENTS ALONE INADEQUATE

We find that the cost of satisfactory flood protection to life and to the property interests of the Miami Valley by channel improvements alone will be so great as to render such improvements impracticable.

We find that the regulation of the Miami River and its tributaries for the protection of life and of the various public and private property interests from the ravages of flood can best be accomplished by the construction of suitable flood reservoirs, together with moderate channel improvements, where needed.

The construction of earth dams, and the impounding of water in reservoirs thus created for the purpose of flood prevention is sound engineering practice:

1. When physical conditions make such reservoirs feasible;
2. When the structures are properly designed, constructed and maintained.

We find the topographical and other physical conditions in the Miami Valley suitable for this purpose.

The proper design, construction and maintenance of these structures is absolutely necessary for the safety of the lives and property lying below them. For this reason, we emphasize the necessity for the greatest caution in each step of the improvement, which must be considered solely on the basis of the welfare of the district, and must be entirely divorced from false economy or political expediency.

We find that the plans outlined by the Morgan Engineering Company for the location and construction of these structures are in general satisfactory.

As detailed plans are not yet prepared, we reserve the right to criticise such plans when completed, to demand any modification in such plans, and to insist upon such care in construction as may be found necessary for the safety of said structures.

RESERVOIRS FOR FLOOD PROTECTION SOLELY

Reservoirs are frequently used for the development of water-power and for other purposes besides flood prevention. Such uses, however, are essentially antagonistic to the purposes for which these reservoirs are recommended in this valley. The use of these structures as "dry reservoirs" to impound flood water only during flood periods and to remain dry during other conditions of flow adds so greatly to their safety and stability that we strongly advise that they be utilized for flood prevention only and not for any other purposes.

Until surveys, plans and estimates are more nearly completed, it is impossible to determine to what extent, if any, collateral channel improvements will be necessary at various points in the valley. We are convinced, however, that by combined action among the several municipalities and property interests, the system of reservoirs proposed will so greatly reduce the cost of necessary channel improvement as to make the total cost of adequate flood protection very materially lower to each separate interest.

CONSERVANCY ACT

No combined action of all of the interests needing flood protection in the Miami Valley is practicable under the present laws of Ohio. The bill now prepared for this purpose, known as the "Conservancy Act of Ohio," seems to fully cover the needs of the situation so far as they can be ascertained at this time, and only by adequate legislation will the necessary combined flood protection works in the Miami Valley become practicable.

In general, the cost estimates of the Morgan Engineering Company seem reasonably sufficient, but the total cost of these improvements can not be closely determined until detailed plans are made and finally adopted. Based on the general estimates so far made, our belief is that the total cost will be reasonable and much below the benefits resulting to the territory to be protected.

We find that the improvements thus far tentatively outlined, if properly installed, would have furnished satisfactory protection to the various municipalities from a considerably larger flood than that of March, 1913.

The system as outlined with such modifications in detail as may be found essential will give safety and security to life and to the property interests in the valley against great floods, and we would advise that the work be continued on the assumption that a reservoir system will constitute the dominant feature of the protection work, which will be supplemented by such moderate channel improvements as may be found necessary in each locality.

As previously stated, the safety of the works proposed is dependent on the care and thoroughness with which the physical facts are determined and with which adequate plans are matured to meet such physical conditions. No false idea of haste should be permitted to detract from the care with which the preliminary work is done. We commend the thoroughness which has characterized the work to the present time, and urge that there be no relaxation of vigilance in securing the maximum safety and economy in the design, construction and maintenance of these important works.

Waterfront Plans for Trenton

FOR its entire length the city of Trenton, N. J., is bordered on the west side by the Delaware River, and plans for the development of the 5-mile waterfront are described by Mayor Frederick W. Donnelly in the Philadelphia "Public Ledger." Bids are to be opened Feb. 20 for deepening the river from Lalor Street to the Pennsylvania Railroad bridge, the excavated material being used for filling low places. It is proposed to improve the Lamberton Street bluff, creating a natural park overlooking the river. Municipal docks are to be built along the unimproved waterfront. A roadway along the river in the southern section from Federal Street to one of the thoroughfares to the heart of the city, a boulevard from the river bluff park to the State House Park and a parallel canal leading from the new docks are part of the project, which it is hoped will be carried through in the next few years.

Strength of Large Pipes

Discussion of Stresses in Circular Conduits with or without Internal Pressure and with Various Widths of Support at Bottom

By D. R. COOPER
Hydraulic Engineer, New York

Assisted by
E. R. WEINMANN

THE customary mathematical analysis to determine the thickness of the shell of a pipe is based upon the assumption that the internal pressure at all points is of equal intensity. For a vertical position of the pipe, for pipes of small diameter or pipes subjected to steam pressure, this assumption is satisfactory, but for water-conveying pipes of large diameters placed in a practically horizontal position this assumption may lead to wrong conclusions. This is due to the fact that the pressure increases appreciably from the top to the bottom of the pipe. As very little information on this subject is available in the English language, the authors have made an extensive research of the foreign engineering publications and the following paper is a compilation of the data obtained. The major portion of the discussion is substantially taken from an article by Phillip Forchheimer in the "Zeitschrift des Oesterreichische Ingenieur und Architekten Vereins."

CHANGE IN SHAPE

The fundamental equation for the change in shape, which a ring takes (for instance, a section of pipe of unit length) reads:

$$\eta + d^2\eta/d\varphi^2 = r^2M/EI \qquad (1)$$

E = modulus of elasticity; I, moment of inertia of section (see Fig. 1); r, radius; M, bending moment tending to deform; φ, central angle (in radians) of an element of the ring measured from an assumed initial point; η, deflection of an element of the ring in direction of radius—that is, increase in the length of radius.

(1) PIPE FULL, NO PRESSURE AT TOP, SUPPORT AT LOWEST POINT

Considering a section of the pipe supported at its lowest point (A in Fig. 2) and completely filled with water but not under pressure—that is, the free water surface should just coincide with the top of the pipe. This is a case recently considered by Birault, using the approximate formula $\eta EI = r^2M$. While this condition of support may never occur, it is valuable for study because it represents the extreme case.

If this section is considered as cut in two at the bottom, that is, at the assumed point of support, there act on the right half of the ring the following forces: (1) Horizontal tension H; (2) a vertical contrary force V, and (3) a moment M_o.

If w represents the unit weight of water, and if ψ for the present be substituted for φ, then it follows (Fig. 3) that at the angle ψ the pressure of the water on $rd\psi$ (a linear element) $= wr^2(1 + \cos\psi)\,d\psi$. The lever arm of this pressure with regard to position φ has the length $r \sin(\varphi - \psi)$ so that the moment about the point φ of all the water pressures acting between 0 and φ may be expressed:

$$\int_{\psi=0}^{\psi=\phi} wr^3(1+\cos\psi)\sin(\varphi-\psi)\,d\psi =$$

$$= wr^3\int_{\psi=0}^{\psi=\phi}(\sin\varphi\cos\psi - \cos\varphi\sin\psi + \sin\varphi\cos^2\psi - \cos\varphi\sin\psi\cos\psi)\,d\psi$$

$$= wr^3\left[\sin\varphi\sin\psi + \cos\varphi\cos\psi + \sin\varphi\,\frac{\sin\psi\cos\psi+\psi}{2} - \cos\varphi\,\frac{\sin^2\psi}{2}\right]_{\psi=0}^{\psi=\phi}$$

$$= wr^3\left(1 + \frac{1}{2}\varphi\sin\varphi - \cos\varphi\right) \qquad (2)$$

To this moment are to be added those of H and V, as well as M_o; accordingly, if the weight of the ring is so small as to be negligible, equation (1) takes the form

$$M = \frac{EI}{r^2}\left(\eta + \frac{d^2\eta}{d\varphi^2}\right) = wr^3\left(1 + \frac{\varphi\sin\varphi}{2} - \cos\varphi\right) - Hr(1-\cos\varphi) - Vr\sin\varphi + M_o \qquad (3)$$

The solution of (3) is

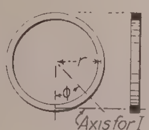


Fig. 1

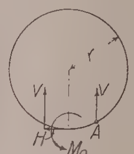


Fig. 2

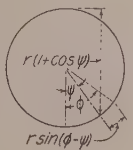


Fig. 3

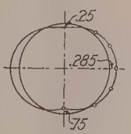


Fig. 4

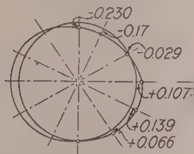


Fig. 5

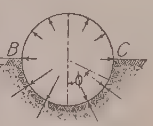


Fig. 6

$$\frac{EI}{r^2}\eta = wr^3\left(1 - \frac{\varphi^2\cos\varphi}{8} - \frac{3\varphi\sin\varphi}{8}\right) - Hr\left(1 - \frac{1}{2}\varphi\sin\varphi\right) + Vr\,\frac{1}{2}\varphi\cos\varphi + M_o + C_1\sin\varphi + C_2\cos\varphi \qquad (4)$$

in which C_1 and C_2 represent two constants to be determined.

Formula (4) may be checked by differentiation, giving

$$\frac{EI}{r^2}\frac{d\eta}{d\varphi} = wr^3\left(\frac{1}{8}\varphi^2\sin\varphi - \frac{5}{8}\varphi\cos\varphi - \frac{3}{8}\sin\varphi\right) + Hr\left(\frac{1}{2}\sin\varphi + \frac{1}{2}\varphi\cos\varphi\right) + Vr\left(\frac{1}{2}\cos\varphi - \frac{1}{2}\varphi\sin\varphi\right) + C_1\cos\varphi - C_2\sin\varphi \qquad (5)$$

Differentiating (5) the result is

$$\frac{EI}{r^2}\frac{d^2\eta}{d\varphi^2} = wr^3\left(\frac{1}{8}\varphi^2\cos\varphi + \frac{7}{8}\varphi\sin\varphi - \cos\varphi\right) - Hr\left(\frac{1}{2}\varphi\sin\varphi - \cos\varphi\right) - Vr\left(\frac{1}{2}\varphi\cos\varphi + \sin\varphi\right) - C_1\sin\varphi - C_2\cos\varphi \qquad (6)$$

Adding (4) and (6) the differential equation (3) follows.

To determine the values of C_1 and H, it may be assumed than $d\eta/d\varphi$ becomes 0 with $\varphi = 0$ and also for $\varphi = \pi$.

From this follows, according to (5), that

$$0 = Vr/2 + C_1$$
$$0 = 5\pi wr^3/8 - \pi/2\,H.r - Vr/2 - C_1$$

or

$$C_1 = -Vr/2 \qquad (7)$$
$$H = 5wr^2/4 \qquad (8)$$

From the condition that the exterior forces must balance, it follows that V must equal the weight of half the contents of the pipe (another V acts on the other half of the section) or

$$V = (\pi/2)wr^2 \qquad (9)$$

Inserting the values of C_1, H and V in (4):

$$\frac{EI}{r^2}\eta = \frac{1}{4}wr^3\left(-1 - \frac{1}{2}\varphi^2\cos\varphi + \varphi\sin\varphi\right) + \frac{\pi}{4}wr^3(\varphi\cos\varphi - \sin\varphi) + M_o + C_2\cos\varphi \qquad (10)$$

Imagine the pipe expanded and then bent on account of the internal pressures. Only those movements (η), due to the bending, are taken into consideration in (4) and (10). In bending, an element of the pipe travels nearly on the line of direction of the radius of its original position, so that between two radii which inclose the angle $d\varphi$ in a full pipe, there is a part of the wall of the length $(r + \eta)d\varphi$.

As no appreciable enlargement of the circumference of the pipe can occur through the bending of the pipe already expanded, it must follow that

$$\int_0^\pi \eta\,d\varphi = 0 \text{ and also } \int_0^\pi \frac{EI}{r^2}\eta\,d\varphi = 0 \qquad (11)$$

The integration of (10) gives:

$$\int\frac{EI}{r^2}\eta\,d\varphi = \frac{1}{4}wr^3\left(-\varphi - \frac{1}{2}\varphi^2\sin\varphi - 2\varphi\cos\varphi + 2\sin\varphi\right) + \frac{\pi}{4}wr^3(\varphi\sin\varphi + 2\cos\varphi) + M_o\varphi + C_2\sin\varphi \qquad (12)$$

Or after inserting the limits π and o, according to (11)

$$0 = \frac{w}{4}r^3(-\pi + 2\pi) + \frac{\pi}{4}wr^3(-2-2) + M_o\pi$$

or

$$M_o = 3wr^3/4 \qquad (13)$$

By inserting in (3) the values of H, V and M_o, which are now known, we get the general expression for the moment:

$$M = \frac{1}{2}wr^3\left[1 - (\pi - \varphi)\sin\varphi + \frac{1}{2}\cos\varphi\right] \qquad (14)$$

According to (14) M is the largest at the point of support, where the pipe has a tendency to flatten. Then M decreases with an increase in φ, becomes larger again and then reduces, as the following tables and Fig. 4 show:

ϕ =	0°	15°	30°	45°	60°	75°	90°	105°	120°	135°	150°	165°	180°
$\frac{M}{wr^3}$	0.750	0.368	0.062	— 0.156	— 0.282	— 0.320	— 0.285	— 0.197	— 0.078	+ 0.046	0.152	0.225	0.250

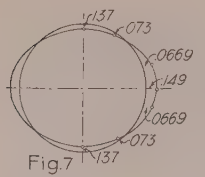


Fig. 7

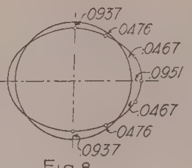


Fig. 8

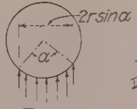


Fig. 9

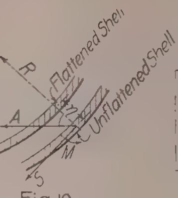


Fig. 10

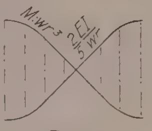


Fig. 11

With this change of curvature occurs a change in length of each diameter. Each diameter reaches from a position φ to a position φ + π and the change length of the diameter at φ is determined by $\eta\varphi + \eta(\varphi + \pi)$. By inserting the value of M_o from equation (13) in (10) it is obvious that:

$$\frac{EI}{r^2}\eta_\phi = wr^3\left(\frac{1}{2} - \frac{1}{8}\varphi^2\cos\varphi + \frac{1}{4}\varphi\sin\varphi + \frac{\pi}{4}\varphi\cos\varphi - \frac{\pi}{4}\sin\varphi\right) + C_2\cos\varphi \quad (15)$$

If φ + π be substituted for φ, this equation is transformed to:

$$\frac{EI}{r^2}\eta_{(\phi+\pi)} = wr^3\left[\frac{1}{2} + \frac{1}{8}(\varphi+\pi)^2\cos\varphi - \frac{1}{4}(\varphi+\pi)\sin\varphi - \frac{\pi}{4}(\varphi+\pi)\cos\varphi + \frac{\pi}{4}\sin\varphi\right] - C_2\cos\varphi \quad (16)$$

By adding (15) and (16) the change in diameter is expressed by:

$$\eta_\phi + \eta_{(\phi+\pi)} = \frac{wr^5}{EI}\left[1 + \frac{1}{8}(\varphi+\pi)^2 - \varphi^2\right\}\cos\varphi - \frac{\pi}{4}\sin\varphi - \frac{\pi^2}{4}\cos\varphi\Bigg]$$

or

$$\eta_\phi + \eta_{(\phi+\pi)} = \frac{wr^5}{EI}\left[1 - \frac{\pi}{8}(\pi - 2\varphi)\cos\varphi - \frac{\pi}{4}\sin\varphi\right] \quad (17)$$

Accordingly (see Fig. 5) it results that for

$\phi =$	0°	15°	30°	45°	60°	75°	90°
$\frac{EI}{wr^5}[\eta_\phi + \eta_{(\phi+\pi)}] =$	— 0.230	— 0.196	— 0.104	+ 0.0084	0.110	0.188	0.214

About one-half of the pipe experiences a reduction and the other half an enlargement of diameter.

(2) PIPE FULL, NO PRESSURE AT TOP, SUPPORTED FOR ENTIRE WIDTH

Pipes laid in the ground are supported throughout the full width. The reaction of the ground acts upon the lower half of the pipe without anything being known as to the direction or size of the reaction pressures, but it may be assumed with practical certainty that the reaction is greatest under the lowest point of the pipe and from this point along both sides up to the level of the axis of the pipe it decreases to zero. Furthermore, the angle between a reaction and the pipe radius cannot be greater than the friction angle between the material of the pipe and the earth. The character of the reaction depends upon the construction of the trench or backfill supporting the pipe. Owing to this uncertainty, an assumption is made which may not be far from the facts and which has the advantage of simplifying the mathematical analysis. Let it be assumed that the reaction against an element of the pipe acts in the direction of the radius and is proportional to cos φ and equal to (a) cos φ. The sum of the vertical components of the reactions is:

$$\int_{-\pi/2}^{+\pi/2} ar\cos^2\varphi\, d\varphi = ar\left[\frac{1}{2}(\sin\varphi\cos\varphi + \varphi)\right]_{-\pi/2}^{+\pi/2} = \frac{ar\pi}{2}$$

or must be equal to the weight of the contents of the pipe, $w\pi r^2$, from which it follows that $a = 2wr$. As the water pressure upon the interior for a unit of area amounts to $wr(1 + \cos\varphi)$ it follows that the resultant of pressure and reaction on the lower half of the pipe must be:

$$wr(1 + \cos\varphi) - a\cos\varphi = wr(1 - \cos\varphi)$$

The water pressure on an element of the pipe located vertically above the one considered is equally large. The pipe section accordingly is stressed and distorted symmetrically with reference to both the horizontal and vertical diameters.

The moment of all the water pressures and reactions between 0 and φ about the point φ is:

$$\int_{\psi=0}^{\psi=\phi} wr^3(1 - \cos\psi)\sin(\varphi - \psi)\, d\psi =$$

$$= wr^3\int_{\psi=0}^{\psi=\phi}(\sin\varphi\cos\psi - \cos\varphi\sin\psi - \sin\varphi\cos^2\psi + \cos\varphi\sin\psi\cos\psi)\, d\psi$$

$$= wr^3\left[\sin\varphi\sin\psi + \cos\varphi\cos\psi - \sin\varphi\frac{\sin\psi\cos\psi + \psi}{2} + \cos\varphi\frac{\sin^2\psi}{2}\right]_{\psi=0}^{\psi=\phi}$$

$$= wr^3(1 - \varphi\sin\varphi/2 - \cos\varphi) \quad (18)$$

At the points B and C (Fig. 6) only vertical forces and moments are transmitted. Accordingly, H must balance the horizontal component of the water and ground pressures of a quadrant. Therefore

$$H = \int_0^{\pi/2} wr^2(1 - \cos\varphi)\sin\varphi\, d\varphi = wr^2\left[-\cos\varphi - \frac{1}{2}\sin^2\varphi\right]_0^{\pi/2}$$

$$H = -\frac{1}{2}wr^2 \quad (19)$$

so that the moment of H about the position φ has the value $-(wr^3/2)(1 - \cos\varphi)$. The differential equation to be solved is:

$$M = \frac{EI}{r^2}\left(\eta + \frac{d^2\eta}{d\varphi^2}\right) = \frac{wr^3}{2}(1 - \varphi\sin\varphi - \cos\varphi) + M_o \quad (20)$$

The solution of this equation is:

$$\frac{EI}{r^2}\eta = \frac{wr^3}{2}\left(1 + \frac{1}{4}\varphi^2\cos\varphi - \frac{3}{4}\varphi\sin\varphi\right) + M_o + C_1\sin\varphi + C_2\cos\varphi \quad (21)$$

And the proof is:

$$\frac{EI}{r^2}\cdot\frac{d\eta}{d\varphi} = \frac{1}{8}wr^3(-\varphi^2\sin\varphi - \varphi\cos\varphi - 3\sin\varphi) + C_1\cos\varphi - C_2\sin\varphi \quad (22)$$

$$\frac{EI}{r^2}\frac{d^2\eta}{d\varphi^2} = \frac{wr^3}{8}(-\varphi^2\cos\varphi - \varphi\sin\varphi - 4\cos\varphi) - C_1\sin\varphi - C_2\cos\varphi \quad (23)$$

As $\frac{d\eta}{d\varphi}$ must become zero both for $\varphi = 0$ and for $\varphi = \pi/2$, it follows (22) that

$$C_1 = 0 \quad (24)$$

$$C_2 = (wr^3/8)(-\pi^2/4 - 3) \quad (25)$$

and in accordance with equation (21)

$$\frac{EI}{r^2}\cdot\eta = \frac{1}{2}wr^3\left(1 + \frac{1}{4}\varphi^2\cos\varphi - \frac{3}{4}\varphi\sin\varphi - \frac{\pi^2}{16}\cos\varphi - \frac{3}{4}\cos\varphi\right) + M_o \quad (26)$$

Furthermore, in order that no change of length of the quadrant may occur

$$\int_0^{\pi/2}\frac{EI}{r^2}\eta\, d\varphi = \left[\frac{wr^3}{2}\left(\varphi + \frac{1}{4}\varphi^2\sin\varphi + \frac{5}{4}\varphi\cos\varphi - 2\sin\varphi - \frac{\pi^2}{16}\sin\varphi\right) + M_o\varphi\right]_{\phi=0}^{\phi=\pi/2} = 0$$

which when the limits are introduced gives

$$M_o = wr^3(2/\pi - 1/2) = 0.137\, wr^3 \quad (27)$$

The combination of equations (20) and (27) shows that the bending moment is

$$M = \frac{1}{2}wr^3(4/\pi - \varphi\sin\varphi - \cos\varphi) \quad (28)$$

which gives the folowing table of values (see Fig. 7):

$\phi =$	0°	15°	30°	45°	60°	75°	90°
$M/wr^3 =$	0.137	0.120	0.073	0.0054	— 0.0669	— 0.125	— 0.149

Equation (27) combined with (26) gives:

$$\frac{EI}{wr^5}\cdot\eta = \frac{2}{\pi} + \frac{1}{8}\varphi^2\cos\varphi - \frac{3}{8}\varphi\sin\varphi - \frac{\pi^2}{32}\cos\varphi - \frac{3}{8}\cos\varphi \quad (29)$$

and as in this case the change in length of diameter, due to the double symmetry must

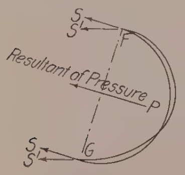


Fig 12

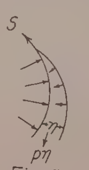


Fig. 13

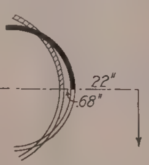


Fig. 14

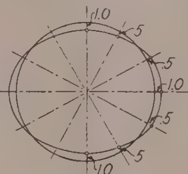


Fig. 15

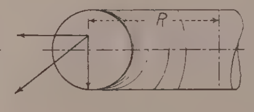


Fig. 16

be equal to 2π, the increase of the diameter may be computed according to equation (29), giving the following values (see Fig. 8):

ϕ =	0°	15°	30°	45°	60°	75°	90°
$2\frac{EI}{wr^3}\eta$ =	— 0.0937	— 0.0814	— 0.0476	— 0.0007	+ 0.0467	+ 0.0820	+ 0.0951

(3) Pipe Full, No Pressure at Top, Any Width of Support

If the pipe is not supported throughout its full width, but only over a central angle of α, a method analogous to that preceding can be made use of. Upon the assumption that the reactions are uniform over the horizontal projection of the circumference and are vertical, the lowest point of the pipe will be subjected to the following tensional force:

$$H = wr^2\left(\frac{5}{4} + \frac{1}{6}\sin^2\alpha\right) \qquad (31)$$

and a moment

$$M_o = wr^3\left[\frac{1}{4}\left\{1 - (\pi - \alpha)\sin\alpha\right\} + \frac{1}{6}\sin^2\alpha + \frac{3\sin\alpha\cos\alpha + \alpha}{8\sin\alpha}\right] \qquad (32)$$

For $\alpha = 0$ the equations (31) and (32) are transformed into equations (8) and (13) but the solution of (31) and (32) is laborious. On this account and because of the uncertainty as to the location of the reactions, as previously mentioned, an approximate and shorter method will be applied.

If in formula (13) (Fig. 2) where a reaction of the support $2V = \pi wr^2$ is added a vertical downward force $2V$, applied at the lowest point of the pipe and also upward forces uniformly distributed over the width $2r\sin\alpha$, formula (13) is transposed into equation (32). The moment Mo at the lowest point (Fig. 9) can be approximately computed, if to the moment of equation (13), (which is $3/4\ wr^3$), is added that of the newly applied forces; that is

$$-1/2\ Vr\sin\alpha = -(\pi/4)\,wr^3\sin\alpha \qquad (33)$$

Assuming that the new forces mostly act upon the lower part of the pipe

$$M_o = 1/4\ wr^3\,(3 - \pi\sin\alpha) \qquad (34)$$

The degree of exactness of this approximate method is indicated by the following comparison of values:

α	= 0°	15°	30°	45°
By formula (32) M/wr^3	= 0.75	0.563	0.420	0.321
By formula (34) M/wr^3	= 0.75	0.547	0.357	0.195

According to these values, the usefulness of the approximate method is doubtful for values of α greater than about 30 deg., but may be applied for values of α smaller than 30 deg., if it is modified by assuming the reactions of the supports not uniformly distributed.

(4) Pipe Under Pressure, Supported Full Width

The investigations already considered were based upon the assumption that the resultant of the outer forces is divided into a moment M and a force K which acts at the center P of the section under consideration. In formula (1) only the moment M was considered, as K was assumed to produce no moment. This would actually be the case if no deflection of the shell would occur. If deflection does occur a moment at the center P_1 of the section of the deformed shell should be investigated, so that in addition to the moment M of formula (1), there is a moment of the force K. Assume the force K divided into a vector force R and a tangential force S. Only the moment of the latter one, $S\eta$, has been neglected above. The tangential force S is so small, assuming the top without pressure, that the neglect of $S\eta$ is permissible. But this condition changes if the water is under pressure. In place of the differential equation (1) the expression

$$\eta + \frac{d^2\eta}{d\varphi^2} = \frac{r^2}{EI}(M + S\eta) \qquad (35)$$

may be solved, although the solution is laborious. In this case an approximate method, which may be developed for the case of the pipe supported for the full width, is used in place of the exact solution. For this load condition it is found that

ϕ =	0°	15°	30°	45°	60°	75°	90°
M/wr^3 =	0.137	0.120	0.073	0.0054	— 0.0669	— 0.125	— 0.149
$2\ EI\eta/wr^3$ =	— 0.0937	— 0.0814	— 0.0476	— 0.0007	+ 0.0467	+ 0.0820	+ 0.0951

from which another series of values is obtained (Fig. 11).

$-2\ EI\eta/Mr^2$ =	0.684	0.678	0.652	0.130	0.690	0.656	0.638

As this series shows $-\ 2EI\,\eta/Mr^2$ is approximately equal to 2/3 (so long as $S = 0$) or

$$\eta = \frac{-r^2M}{3EI} \qquad (36)$$

If instead of M smaller moments αM occur (α constant), all deflections must decrease in the same proportion. Their value is $\alpha\eta = -(r^2\alpha M)/3EI$. A moment (αM) may be produced if a force S with the lever $\alpha\eta$ is assumed acting in addition to the original moment M, and if

$$\alpha\eta = -r^2(M + \alpha\eta S)/3EI \qquad (37)$$

where the absolute value of $M + \alpha\eta S$ is smaller than M, because η has the opposite sign from M.

From equation (37) it follows that

$$\alpha\eta = -r^2M/(3EI + Sr^2) \qquad (38)$$

gives the amount of deflection produced if the tangential force S, with the distances $\alpha\eta$ from the deflected shell (equal to the deflections) is introduced. These forces, therefore, act in the unflattened shell. The latter condition occurs if the water is under the pressure

$$P = S/r \qquad (39)$$

That the pressure also enlarges the pipe need not be considered, since the shell is first stretched and then bent and because it is of no importance whether r is introduced in formulæ (38) and (39) as the initial or final radius. It remains to be proved that the pressure p produces stresses $S = pr$ in spite of the deflection of the section from a true circle (Fig. 12).

Imagine the stresses acting along the unflattened circumference. Consider the bent and unbent half of the pipe between the points F and G common to both. The water pressures p on both halves have the same resultant, normal to the diameter FG common to both, and only two symmetrical forces can balance this resultant. For the circular section these two forces parallel to the resultant are S. The other section is unsymmetrically deflected, so that its reactions are revolved with regard to S like the forces S', which is only possible because of the symmetry, if the revolution amounts to 0, or the forces S' coincide with S. If each of the forces S consecutively is combined with each of the forces p of the circular pipe, a tension S in the circle will be the result.

In order to get the stress in the deflected section at the location η imagine the space between the two shells filled with liquid under the pressure p. The new pressures p then act on a series of areas, continuous except for the length η, balancing each other except for the resultant which has the value $p\eta$ and is normal to η. As the moment with regard to the flattened shell is $p\eta^2/2$ it may be neglected, since η is very small and is in the second power. The assumption that S does not change either on account of the location or amount of the deflection is, therefore, practically correct.

The formula (38), which gives the coefficient

$$\alpha = EI/(3EI + Sr^2) \qquad (40)$$

and indicates the decrease of the deflection for an inward pressure is of special importance, because it shows that an increase of the water pressure in a horizontal or slightly inclined pipe may produce a decrease in the maximum tensile stresses of the shell. If δ is the shell thickness the moment $M + \alpha\eta S$ (where M and η have opposite signs) produces a tensile stress in the extreme fiber

$$\frac{6}{\delta^2}\cdot\frac{3EI}{3EI + Sr^2}\cdot M$$

where

$$I = \frac{\delta^3}{12}$$

and where the force S produces at the same time another force S/δ so that if M is only the absolute value of the moment, the tensile strength equals

$$s = \frac{6}{\delta^2}\cdot\frac{3EIM}{3EI + Sr^2} + \frac{S}{\delta} \qquad (41)$$

Here the weakening on account of riveting is not considered. In this case it is recommended to insert the rivets at the 45-deg. points.

The differentiation gives

$$\frac{ds}{dS} = -\frac{18EIMr^2}{\delta^2(3EI + Sr^2)^2} + \frac{1}{\delta} \qquad (42)$$

For $S = 0$ the different quotient becomes $-(1/\delta)\left[(2Mr^2/\delta EI) - 1\right]$ and is therefore negative when

$$2Mr^2 > \delta EI \qquad (43)$$

In this case the pressure in a pipe not previously filled results in a decrease of the total unit stress s and reduces possible danger of rupture.

The pipe acts to a certain degree like a hose made of a flexible material expanding with the water pressure and whose shell the pressure protects from dangerous sharp bending. The increase of safety with the water pressure continues until $ds/dS = 0$, or the stress in the shell reaches the value

$$S = \frac{3\,EI}{r^2}\left(r \cdot \sqrt{\frac{2\,M}{\delta EI}} - 1\right) \qquad (44)$$

Under this condition s is a minimum. With the increase in pressure the danger of bursting increases again. An example will illustrate the conditions. A pipe 5 ft. 3 in. in diameter ($r = 31.5$ in.) is embedded for its full width. Then by filling it with water ($w = 0.0362$ lb. per cubic inch) a bending moment is introduced at the elevation of the surface equal to $-0.0149\,wr^3 = 168$ in.-lb. per linear inch of pipe. This moment causes on the outside of the shell (the shell thickness $= 0.315$ in. and the section modulus 0.0166 in.^{3}) a tensional stress of 10,000 lb. per square inch.

The horizontal radius increases by an amount $\eta = 0.0475\,wr^5/EI$, which gives (if $E = 30{,}000{,}000$ lb. per square inch) $\eta = 0.68$ in.

At the end of the horizontal radius a vertical tensional force acts within the shell balancing the pressure acting on a quarter of the pipe and amounting to $wr^2(1 - p/4)$. That is only 7.6 lb. and of no importance. Unite force and moment into a single force, also 7.6 lb., which acts upon the shell section at a lever arm: $168/7.6 =$ about 22 in.

Considering the length of this lever arm, it is of no importance whether it is measured from the original or from the deflected shell, but if there is a pressure of 65.6 ft. or 28.5 lb. per square inch, the case is different. The tension in the shell then increases to $S = 28.5 \times 31.5 = 900$ lb. per linear inch of pipe and brings the resultant of moment and single force near to the shell. If the deflection were not changed, then the force S (which must be imagined as lying in the original shell) would act upon the deflected shell with a moment of $900 \times 0.68 = 612$ in.-lb., acting in the reverse of the above computed 168 in.-lb. But moments and deflections decrease according to equation (40) to the fraction

$$234{,}000/(234{,}000 + 900 \times 990) = 0.211$$

of the preceding value,

so that η in the elevation of the pipe axis amounts to $0.68 \times 0.211 = 0.144$ in. and M only $168 \times 0.211 = 35.5$ in.-lb. The tensional stress caused by M is $35.5 \div 0.0166 = 2140$ in.-lb. and $S = 900/0.315 = 2680$ lb. so that altogether $s = 5000$ lb. per square inch as against the preceding 10,000 lb. s is smallest by equation (44) for $S = 635$ lb., the inside pressure becomes $p = \frac{S}{r} = \frac{635}{31.5} = 20$ lb. per square inch, for which the corresponding s amounts to $2800 + 2000 = 4800$ lb. per square inch.

(5) STRESSES FROM EARTH PRESSURE

For the computation of the stability of pipes against earth pressure, it is simplest to assume a uniformly distributed vertical pressure q over the horizontal projection of the outside and also a uniformly distributed horizontal pressure of q_1 over the vertical projection. It is further assumed that the reactions of the earth in the lower half of the pipe are also uniformly distributed and also equal to q and q_1. The horizontal earth pressure is generally assumed at one-fifth to one-third of the vertical pressure. An increase of the earth pressures downward may be taken into consideration as follows: Determine q based upon the average height t of the top; q_1 based upon the average height t_1 of the skewbacks; the earth weighs w^1, then $q = w^1 \times t$, $q_1 = 1/5$ to $1/3\,w^1t_1$. There exists symmetry with respect to horizontal and vertical diameters and at the top and bottom each half of the pipe acts upon the other with a certain pressure, q_1r, using the preceding notations.

For the moment we get

$$M = \frac{EI}{r^2}\left(\eta + \frac{d^2\eta}{d\varphi^2}\right) = -\frac{qr^2}{2}\sin^2\varphi +$$

$$q_1r^2\,(1 - \cos\varphi) - \frac{q_1r^2}{2}(1 - \cos\varphi)^2 + M_o$$

$$= -(q - q_1)\frac{r^2}{2}\sin^2\varphi + M_o \qquad (45)$$

The solution of (45) becomes

$$\frac{EI}{r^2}\eta = -(q - q_1)\frac{r^2}{6}(1 + \cos^2\varphi) + M_o$$
$$+ C_1\sin\varphi + C_2\cos\varphi \qquad (46)$$

and

$$\frac{EI}{r^2}\cdot\frac{d\eta}{d\varphi} = (q - q_1)\frac{r^2}{3}\sin\varphi\cos\varphi$$
$$+ C_1\cos\varphi - C_2\sin\varphi \qquad (47)$$

because for $\varphi = 0$ or $\frac{\pi}{2}$ the differential quotient must become zero, therefore, $C_1 = C_2 = 0$, or

$$\frac{EI}{r^2}\eta = -(q - q_1)\frac{r^2}{6}(1 + \cos^2\varphi) + M_o \qquad (48)$$

and considering that one-fourth of the circumference cannot change its length, we get

$$\frac{EI}{r^2}\int_{\phi=0}^{\phi=\pi/2}\eta\,d\varphi = 0 \qquad \text{or}$$

$$\left[-(q - q_1)\frac{r^2}{12}(3\varphi + \sin\varphi\cos\varphi) + M_o\varphi\right]_0^{\pi/2} = 0 \qquad (49)$$

which gives

$$M_o = (q - q_1)\frac{r^2}{4}$$

This expression for M_o may also be obtained by using the approximate differential equation

$$M = \frac{EI}{r^2} \times \frac{d^2\eta}{d\varphi^2}$$

The combination of (45) and (49) gives (see Fig. 15):

$$M = (q - q_1)\frac{r^2}{4}(1 - 2\sin^2\varphi)$$
$$= M_o(1 - 2\sin^2\varphi) \qquad (50)$$

According to equation (50) the curvature flattens on top and bottom and sharpens at the skewbacks. From equations (48) and (49) it also follows that the radii deflect by an amount

$$\eta = \frac{(q - q_1)\,r^4}{12\,EI}(2\sin^2\varphi - 1) \qquad (51)$$

that is, the vertical diameter decreases and the horizontal increases, each by an amount of $\frac{(q - q_1)\,r^4}{6\,EI}$.

(6) CONCLUSIONS

The preceding developments show that the moments due to the unequal water pressures increase in proportion to r^3. The reduction of the vertical diameter is in proportion to r^5. These pressure differences between top and bottom, therefore, may be of some importance only for large horizontal pipes. If the diameter is so large that the computation in the ordinary way (that is, the computation for simple tension) is not sufficient, then the bending moments increase very quickly with the pipe diameter. The above-mentioned formulæ give, without further consideration (if a variation of the coefficients of elasticity is neglected) the necessary shell thickness, under the condition that the elastic limit is not exceeded. This is the more important if the material is brittle, that is for conduits of cast iron, vitrified clay and concrete.

Otherwise, if an extensible material, such as wrought iron or steel, is used for full pipe and no pressure at the top, the greatest moment will be at the top (the limiting values of which have been determined to be $0.75\,wr^5$ and $0.15\,wr^5$), independent of the extension values, but not for a full pipe under pressure at the top. The pipe shape then changes so much that the moments decrease, for instance, for conduits bedded in earth, in proportion to

$$\frac{E\,\delta^3 + 4\,pr^3}{E\delta^3}$$

Such a pipe may resist larger inside pressure the smaller the modulus of elasticity E. Its elasticity is therefore favorable. The more elastic the shell, the more the first member of the formula (41) for the tensional stresses due to the moment alone, decreases, that is,

$$s = \frac{6\,E\delta^4M}{\delta^2\,(E\delta^4 + 4\,pr^3)} + \frac{pr}{\delta}$$

and the more can the strength against the tensional stress as opposed to the force $S = pr$ be utilized. It is, therefore, not unsafe for an extensible material, if the elastic limit is somewhat exceeded in a pipe free of pressure at the top and indeed it must have been exceeded for conduits of wrought iron and steel. A wrought-iron pipe at Champ is bedded in concrete well above the skewbacks but is top filled only 15.7 in. and has 0.275 to 0.59-in. shell thickness for a diameter of 10.8 ft. Some wrought-iron single-riveted pipes supported on cement mortar saddles with 10 ft. per second velocity have only 0.315-in. shell thickness for 10 ft. diameter (Hafslund).

For the conduit at Champ, $w = 0.0362$, $r = 65$ in., $q = 2.24$ lb. per cubic inch, $q_1 = 0.55$ lb. per cubic inch. Equation (29) gives a top moment $M_o = 1350$ in.-lb. and equation (49) gives a further moment $M_o = 716$ in.-lb., so that for the pipe full but with no pressure at the top each pipe ring of 1/3-in. axis length and 0.275-in. shell thickness or section modulus of 0.0127 in. has to resist an acting moment of $1350 + 716 = 2066$ in.-lb. The lower concrete shell may somewhat decrease the bending moment, acting at the top, which is not concreted, but the above obtained results show that a large deflection must occur. The passing beyond the elastic limit must have occurred when the pipe was laid in the trench. A photograph taken during construction shows an extreme flattening. The theoretical proportion of the horizontal diameter to the vertical diameter is at least 1.2 to 1.

Centrifugal forces also create conditions of stress similar to those due to the action of gravity, or may add their influence.

In addition to the weight of a cubic inch of water $w = 0.0362$ lb., a centrifugal force is added at curves. If a cubic inch of water flows through a bend of the radius R, with a velocity of v ft. per second, the centrifugal force acts outward from the center of the bend and is equal to $0.0362\,v^2/32.2\,R$.

Centrifugal forces and gravity unite according to the parallelogram of forces and in effect change the vertical weight of the liquid into a larger and inclined weight. Finally the inside pressure of the water may combine in several ways with the outside pressure of the back-filled earth. There is, therefore, the unfavorable condition that the component of the earth pressure at the top acting against the water pressure is the largest just where the other is the smallest and that the outside pressures of earth as well as the inside pressure of the water flatten the pipe in its vertical direction, so that unequally distributed water pressures, centrifugal forces and earth pressures have the same deforming tendency on a horizontal pipe.

The foregoing discussion is not to be taken as covering the case of stresses in pipes supported on saddles. In such cases the action of the pipe structure as a beam must be taken into consideration and the stresses modified accordingly.

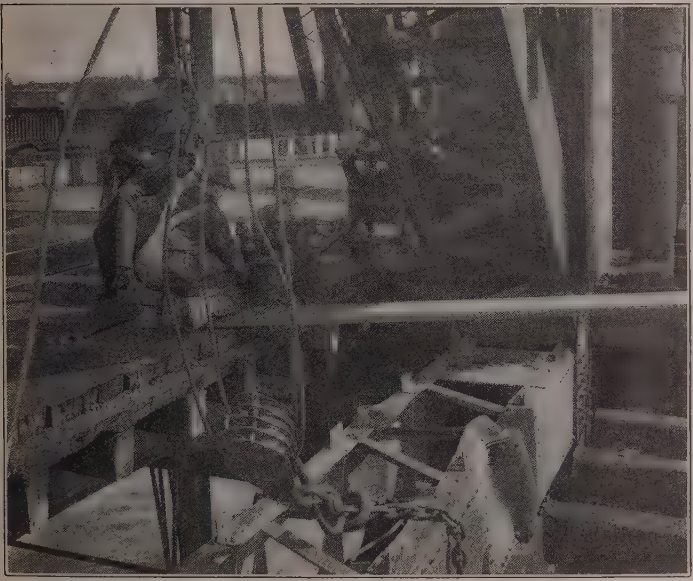
Pneumatic Methods for Finding Flaws in rock indicate whether or not the rock is pervious, but they do not locate the seams. An elaboration of this method is to attach rubber washers to a mouthpiece and by means of them close off a small part of the hole and thus locate possible seams. This procedure, however, is tedious and a method used near Augusta, Ga., for the investigation of the foundation for the dam of a hydroelectric project is claimed to be more economical. Here test holes were drilled into the granite—which was the prevailing rock formation—and dye forced into the holes. In subsequent core-borings the color showed where flaws existed. The method proved satisfactory in that the character of the ledge was known in advance, and thus obviated unnecessary drilling and excavation.

Repairing Fire Damage on the Harriman Bridge at Portland, Oregon

Methods Employed in the Removal and Replacement of Badly Injured Parts and in the Lining Up of Minor Distortions

Repairs have been completed on the two-level Harriman Bridge across the Willamette River at Portland, Ore., which was damaged by fire on the afternoon of July 30, 1913, as reported in the Engineering Record of Aug. 9, 1913. The bridge is used by the Oregon-Washington Railroad & Navigation Company and the Southern Pacific Company. It has a 211 ft. lift span, on either side of which is a fixed span 287 ft. in length, and is built entirely of steel, with the exception of the floor system on the upper deck.

The fire originated on the under side of the upper-deck floor system and swept under about 800 ft. of the roadway, meantime heating parts of the steelwork to such an extent that they were warped and distorted, or crowded out of shape by other expanding members. That no serious damage was done to the more important members is shown by the facts that trains were operating safely on the lower deck on the day following the fire and that the lift span was operated and street cars were allowed on the upper deck within three days. More than two months were required, however, to complete repairs and line up distortions.



Buckled Top Chord Strut Just before Removal

Rear Tower Post Distorted by Heat of Fire

Origin of Fire

While the origin of the fire has not been determined, it may have been one of several causes, as prior to the fire the weather had been very hot and paving pitch and creosote had been noticed oozing from the timbers and dripping from the upper deck. Once started this oily fuel burned with a heat so intense that the expansion in the bottom chords and floor stringers of the lift span amounted to about 9 in., it is reported, indicating a heat in these members of 360 or 400 deg. Fahr. This increase in length of the lift span pushed the main columns of the towers apart about 9 in. at the upper floor level. The rigidity of the tower bracing, however, held the towers practically vertical above the upper deck, the top-chord struts of the end panels in each fixed span taking almost all of the distortion. The fact that no damage was sustained by the towers themselves was due, it is believed, to the giving way of these unimportant members, which were of comparatively light construction, and, being very hot at the time, readily yielded to the pressure and thus took up the distortion at a point not vital to stability.

Important Members Distorted

The most important members of the structure to be distorted were the south rear leg of the west tower and the north rear leg of the east tower. These members, each of which consisted of two 15-in., 33-lb. channels with angle lacing, were damaged by the burning of the watchmen's houses, which stood against the steel in each case. The burning of the watchman's house on the west end caused the steel partly to collapse, shortening the member about 1½ in., while the corresponding member on the east end was distorted slightly without shortening.

On the west tower it was necessary to place jacks under the member to return it to position and take the strain, while a distorted section about 8 ft. long was cut out with the aid of oxyacetylene torches. The new channels put into this gap were of the same size and weight as those taken out, and were spliced in by ½-in. cover plates placed both inside and outside.

The corresponding damage on the east tower was not so serious, and here the old channels were left in place, ½-in. splicing plates being put on inside and outside, however, as on the west tower. Cover plates of ⅜-in. thickness would have given ample strength, it is said, because these members carry comparatively light loads and serve chiefly as bracing members. It was deemed advisable, however, mainly on account of appearance, to use nothing less than ½-in. plates in repairing these tower members.

It was thought best to substitute entirely new members of full panel length for the top chords of those panels next to the lift span where the 9 in. expansion had been taken up. Accordingly the crumpled steel was cut out by the oxyacetylene torch. When the first cuts were made the tower posts sprang forward toward their correct positions, the movement amounting to about 1 in. Each panel was about 3½ in. short of correct length, however, and to move the tower posts this remaining distance two 14 x 14-in. timbers were swung into position just below the top-chord level and parallel to it. On the end of each timber a 70 ton hydraulic jack was attached so as to thrust against the tower post, while the other end of the timber was braced against the upper-chord panel point in the fixed span. With this arrangement the tower posts were easily moved back the 3½ in. necessary to bring the panel to correct length, when the new member was at once put in place and the connections bolted up. After this substitution of new struts for those distorted by the fire, the vertical alignment of the towers was checked with a transit and found to be correct.

The upper flanges of the end floor beams in both the fixed spans adjacent to the lift span were found to be warped in a horizontal plane due to the center of the beam being held in place by the stringers while the ends were thrust back by the expanding chords of the lift span. The lower flange of this floor beam was held straight by a horizontal truss used for bracing between tower posts. All that was required to repair this floor beam was the substitution of a new top flange, as the web was easily sprung back into place after the old flange was removed.

Oxyacetylene torches were used to cut some of the stringers which were wedged by distortion, while others were straightened by the use of a hydraulic jack, and left in place. The warped webs on some of the stringers could not be flattened either by pressure or blows, and were cut by the torch to relieve internal stress, and then bent into shape. In such cases cover plates were riveted over the cut webs to give the necessary strength.

Eight of the cables suspending the end cross-beams of the lifting deck were burned through, and on account of the slight clearance in the sheaves it was not practicable to splice these. New cables were therefore placed in the old sockets. When put into service the cables had links in the ends so that when permanent stretch has been attained this can be taken up by removing the links. One of the four suspending cables which run to intermediate points of the lifting deck on the north side was also damaged and replaced. After the burning through of the eight 1½-in. cables the smaller counterweights which these cables supported were prevented from falling by the heavy tie-link or spacer bar which connected them to the main counterweights for balancing the lifting deck.

Practically the only other damage to operating mechanism was the burning off of the electric wires of the power and signaling systems, and these were either spliced or replaced entirely, as required. The lift span could have been operated the day after the fire, it is reported, had it not been for delay in threading the new cables. Suitable cables, 1¼ in. in diameter, were found in the Portland stock of the John A. Roebling's Sons Company, and delivered at the bridge two hours after the fire was out. It was considered advisable, however, to carry on the work of replacing these only during daylight hours.

Deck

Prior to the fire the wooden deck consisted of creosoted-fir floor beams resting on steel stringers and supporting a solid floor of creosoted-fir planking, 4 in. thick, on which 4 in. paving blocks of the same material were laid. The sidewalks were of 2½ in. fir plank not treated. Over the larger part of the floor system that was damaged the fire was extinguished before it had time to do more than consume the oil on the surface and burn into the wood enough to char the ties to a maximum depth of about 1 in. The overlying planking was damaged to a less extent.

Before renewing the burned floor system the feasibility of replacing it with a concrete floor system was considered and found to be impracticable because the resultant stresses, while not in excess of the safe loading of the bridge, would reduce the allowable live loading on the upper deck to an undesirable extent. The expedient of placing No. 20 galvanized steel plates on top of the 7x9 in. floor beams was therefore adopted, and on these plates the fir planking was placed as before. Another safeguard adopted was to fill in between the floor beams wherever they rested on stringers, so as to close the air space above the stringer, and thus divide the floor system into pockets to prevent the possibility of a cross draft in case of fire. The paving blocks as well as all timber used in the new floor system were treated by the carbolineum method instead of being creosoted.

Fires are reported to have started at various times on bridge sidewalks in Portland, and in renewing the walk on the Harriman Bridge it was decided to use some protection for the planking. Untreated timber was therefore used, and Watsonite, a patented paving mastic, was laid on the walk over the entire bridge.

No Water in Mains

The fact that there was no water in the fire-protection mains on the bridge when the fire started was a serious handicap, it has been said. The city had objected to allowing pressure to be kept in these mains on account of the likelihood of freezing the pipes or wasting the water in leakage. When the fire was discovered it was therefore necessary for the watchman to go about 1100 ft. to reach the valve which turned pressure into the mains. When the watchman got back to the fire-hose it had been burned in two near the connection. In the repair of the bridge a complete rearrangement of fire mains has been effected.

The Harriman bridge was constructed a little more than a year ago by the American Bridge Company according to designs prepared by Waddell & Harrington, consulting engineers, of Kansas City, Mo. The entire cost of repairing the recent fire damage was about $60,000, the steelwork being more expensive than would ordinarily have been the case on account of emergent conditions. The work was handled by force account by the Robert Wakefield Company, of Portland. The 70 tons of steel used in making the repairs were fabricated by the Northwestern Steel Company, of Portland, and placed in the bridge under the direction of Mr. W. H. Alderson, bridge engineer for the Oregon-Washington Railroad & Navigation Company. Mr. George W. Boschke, chief engineer for the railroad, had general charge of the entire work of repairing the fire damage, and personally supervised much of the work on the bridge.

To Pump New York's Water Supply?

Merchants' Association Is Investigating Conversion of Gravity Supply to Pressure System

CONVERSION of the Croton-water supply of New York City from a gravity to a pressure system is the subject of a letter which the Merchants' Association of New York is sending to real estate owners and lessees, from whom information as to cost of pumping and uses of water is solicited. The data are being collected by Mr. James H. Fuertes, consulting engineer.

A considerable percentage of the water supplied to New York from the Croton watershed, the letter states, is now pumped by the city to supply districts too high to be reached directly by the water from the aqueducts. A further large proportion is pumped from the street mains to elevated tanks in buildings by owners or lessees of business and residence properties at considerable private expense. Lack of sufficient pressure in a large part of the territory served prevents the extensive installation of automatic sprinklers and water curtains, and therefore insurance rates are much higher than they should be.

The Merchants' Association proposes to make an examination of these conditions to determine the desirability of recommending the conversion of the Croton-water supply from a gravity to a pressure system, and to show how such a change would affect the public cost by the increased pumping required, how it would affect the individual costs by abolition of private pumping, and how it would affect insurance outlays by making possible a more extensive use of automatic sprinkler systems.

Activities of the Sanitary District of Chicago

SUMMARIES of work completed in 1913 and now under way by the Sanitary District of Chicago, as given in the preliminary message of the President, state that work is progressing on nine sections of the Calumet-Sag Channel, leaving only 4 miles to be contracted for. Seventy feet of bank, 1,500,000 cu. yd., of the Main Channel for a distance of 5 miles were removed between the eight-track bridge and Summit at a cost of $440,000. About 1½ miles of this work remain to be done and an additional 22 feet along the entire distance must be removed to make the earth channel equivalent to the rock cross-section. The North Shore Channel banks have continued to slide, making it necessary to redredge great quantities of earth each year and deposit it 8 miles into the lake. In 1913 about 160,000 cu. yd were removed at a cost of $107,000. A $375,000 conduit to intercept the sewage of the North Shore towns from Wilmette to Glencoe is under way. Similar conduits to exclude the Evanston and Calumet sewage from the lake will receive early attention.

About 121,000 cu. yd. of septic sludge have been removed from Bubbly Creek, the various firms in the stock yards contributing for the first time to defray the expense. A report from the experiment station on recommendations as to caring for these trade wastes is promised at an early date.

Reinforced-Concrete Roof Trusses and Cantilevered Balconies

Six-Story Building, 232 x 164 Feet in Plan, for Assembling Automobiles

OVER the central inclosed court of an automobile assembling plant of the Ford Motor Company in Chicago is a skylight supported on reinforced-concrete roof trusses and at the sides are cantilevered platforms projected from each floor to be served by an overhead traveling crane. This structure is 232 x 164 ft. in plan, six stories high, and is one of fourteen buildings of Akme design being erected for the same company in as many different cities. The columns are spaced on 28 x 25-ft. centers and support 11-in. flat-slab floors.

A railroad track running practically the full length of the building, with the track level 4 ft. below the second floor, is supported by two lines of reinforced-concrete girders of 28-ft. spans, one line of girders being carried by brackets on the main columns and the other line resting on an independent line of columns. These girders form a through bridge, with the track carried by the slab level with the bottoms of the girders. The track structure is 13 ft. wide in the clear, and as the main columns are 35 ft. apart transverse to the railroad track the second floor forms a wide shipping platform on one side between the track and the columns.

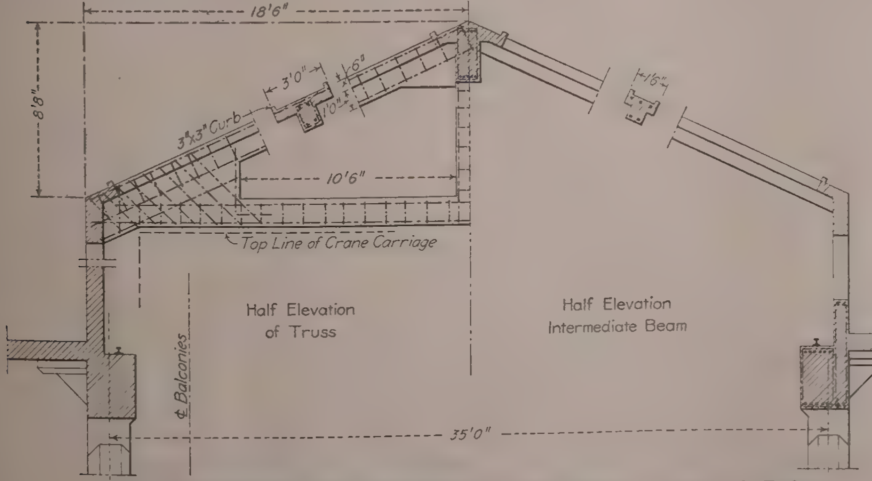
CANTILEVER PLATFORMS

Above the railroad track at the second floor is an open well, about 205 ft. long by 30 ft. wide, covered by a roof monitor the full length of the building above the sixth story. The cantilever platforms extend out into this well from each floor 8½ ft. beyond the column centers and are a half panel, or 14 ft. long at the sixth floor. They increase in length by 14 ft. at each story below the sixth floor, so that on the third floor they extend in front of two panels a distance of 56 ft. The balconies are 11-in. concrete slabs of the same thickness as the main floor, and are merely extensions of the floor slabs without supporting girders. A load test was made on one of the fourth-floor balconies, which was 1½ panels long. The test load consisted of 110,000 lb. of cement, giving a load of 2600 lb. per linear foot of balcony, or 310 lb. per square foot of balcony area. After this test load had been in place twenty-four hours the maximum deflection was 5/32 in. at the outer edge. All concrete was mixed in the proportion of 1 part Universal Portland cement, 2 parts sand and 4 parts gravel.

Skylight over Aisle

The monitor skylight over the craneway is supported by reinforced-concrete king-post trusses having a span of 35½ ft. and a depth of 10 ft. The trusses are spaced on 28-ft. centers, with a continuous longitudinal girder at the ridge. Four reinforced-concrete rafters of T section in each bay between the trusses are placed parallel to the trusses, 8 ft. 10 in. apart. The glass skylights are carried directly on these rafters and the top chords of the main trusses. Falsework for the trusses and rafters was supported by diagonal shoring from the sixth floor and from the reinforced-concrete crane girders at the roof level. Estimates by the engineers indicated that it would be cheaper to build these trusses and rafters of reinforced concrete than of structural steel fireproofed with concrete. The gable at the north end of the roof monitor consists of a concrete wall reinforced as a beam and arched on its under side to conform to the architectural design of the building.

The architect for the building was Mr. John Graham, supervising architect for the Ford Motor Company. The structural design was made by the Condron Company, engineers, Chicago. Mr. E. L. Scheidenhelm, of Chicago, was the general contractor.



Sectional Elevation with Reinforced-Concrete Roof Truss and Rafter

Fenders on Motor Trucks

Protection for Pedestrians Required by Ordinance in Detroit

By PATRICK W. KEATING, Detroit

ON July 18, 1913, there was introduced in the Detroit City Council an ordinance requiring that all motor trucks of 1 ton or greater capacity be equipped with fenders. The proposed enactment read that the fenders should be "designed to catch and sustain any human being who may be in the way of such car, and so mechanically constructed that said fenders may be lowered or raised by the operator in charge of said motor vehicle truck, or such other fenders as may be deemed best to carry out the intent of this ordinance, such fenders to be of such design as the police commission shall have certified in writing meets with their approval." The fine imposed for violation was from $10 to $100, with or without imprisonment not exceeding 90 days in the House of Correction for each offense. Each day's violation constituted a separate offense.

TRUCK OWNERS PROTEST

This ordinance was passed and given immediate effect, in spite of the protest of truck owners, who began at once to remonstrate against its enforcement, using every means, political and persuasive, for delay. They succeeded in having the council instruct the police commissioner to postpone enforcement until Nov. 1, and again till Jan. 1, 1914. At present the ordinance is in effect, and the police commissioner says that from now on it will be rigidly enforced. His action will be watched closely by thousands of citizens whose lives are in constant danger in a city teeming with motor cars.

The contention of owners that there is not one effective fender on the market is not borne out by the manufacturers of motor cars, who have no objection to the ordinance. Owners have asked for delay on the ground that their drivers would strike. This has proved a subterfuge.

The police department, at the outset, equipped its trucks with what it considers an efficient fender at a cost of $22.50 each, and in response to an advertisement for fenders the prices ranged from $42 to $22.50 for each, attached.

The ordinance brought out the fact that while the fender may be a standard for all cars, no standard of attachment can be specified. The make and arrangement of forward trucks of the cars govern the style of attachment.

APPROVAL OF FENDER

Five manufacturers of fenders have secured the approval of the police department. Before a fender can be approved it must be attached to a truck of the style or make on which it is to be used and then submitted, with a photograph of the fender so attached, for approval. The approval is written on the back of the photograph if the fender complies with the ordinance. The acceptance of the fender for one type or style of truck does not necessarily cover its application for other makes or styles. There are no specifications for the fenders, but the provision of general safety is the requirement. They must be not more than 6 in. above the surface when in operation, which means that there must be an adjustable apron. The fender manufacturers say, according to the police department, that the truck owners took advantage of the time extension made by the city council and did not place orders for fenders. Consequently, a large number are not equipped so as to comply with the law.

PETITION PRESENTED

Alderman Vernor, who is a truck owner and opposed to the ordinance, presented to the Common Council on Jan. 6 the following petition in behalf of the Voigt Brewery Company and seventeen other owners:

"We, the undersigned owners and operators of motor trucks, hereby petition your honorable body to repeal the ordinance known as the fender ordinance for the following reasons:

"1. No practical fender has, as yet, been designed for use on motor trucks.

"2. The best fenders now being used do not prevent loss of life or serious accidents to persons.

"3. Fenders, when in position to operate with any degree of safety, are so close to the ground that they will strike the ground and break whenever the wheels of the truck pass over any ordinary obstruction in the streets, such as street-car tracks or street crossings.

"4. When the lower part of the fender is folded against the upper part of the fender to prevent striking on the ground it is not only useless as a safeguard to life, but if it strikes the body of a person thrown to the ground it will roll the body under the truck.

"5. Constant breakage of fenders and consequent expense without providing the safety which was intended are unnecessary burdens on truck owners. Such an expense will, from present indications, exceed $100 per annum.

"We also wish to assure your honorable body that we are heartily in accord with any plan which may be devised and approved by competent engineers that will actually provide safeguards against injury to life and limb on the streets, and when such is adopted and made a law we will give you thorough and effectual co-operation in its observance; and we sincerely hope that you may see your way clear in the repeal of the present ordinance to frame another ordinance which will be comprehensive in providing safeguards against the operation of all kinds of vehicular street traffic."

The petition was referred to the ordinance committee. Efficient truck drivers of the larger plants using cars with fenders claim that the breakage of fenders, as claimed by the petitioners, is due to lack of care and inefficiency of the drivers. In City Hall circles the belief is general that the protest is of a mercenary nature and that the ordinance will not be repealed.

FLOOD-PROTECTION PLANS for Marietta, Ohio, according to Mr. W. J. Sherman in a paper read at the Michigan Engineering Society on "Flood Protection in Ohio," will show drawings and estimates for full protection by means of levees, partial protection by means of a low-levee system, and also by raising the grades of important streets above all ordinary floods. Marietta, located at the confluence of the Ohio and Muskingum Rivers, was damaged by floods last March to the extent of $1,500,000. The business section was submerged 20 ft. and about 42 per cent of its area was under water.

Indexing Data on Stream Flow and Rainfall

Method Used for More Than Four Years in Library of Engineering Firm Specializing in Water-Power Investigation

By LOUISE B. KRAUSE

Librarian, H. M. Byllesby & Company, Chicago

TO every engineer making investigations of irrigation and hydroelectric projects stream-flow records are indispensable, but the printed data are so widely scattered that the information sought is not always easily obtainable. It is apparent, therefore, that the indexing of these data for ready reference is of first importance. The suggestions in this article are intended not for the expert librarian but for the engineer who has small collections of specialized material which it is necessary for him to care for personally without the assistance of professional library service.

SOURCES OF INFORMATION

The principal source of information on stream flow is the publications of the U. S. Geological Survey, particularly the series known as "Water Supply Papers," although stream-flow data have also been published by the Geological Survey in its annual reports and bulletins. Since 1906 the publication of these data has been systematized and enlarged, and the gage heights of a large number of rivers, with rating tables, have been published annually in groups in the water-supply papers under their respective watersheds, for the United States has been divided by the Geological Survey into twelve divisions, whose boundaries coincide with the natural drainage lines of the country.

In addition to these annual numbers, which are known under the general title of "Surface Water Supply of the United States," the Geological Survey has published various papers, also included in the Water Supply Series, on the water resources and water powers of certain States and regions, which supplement the stream-flow records printed in the annual Surface Water-Supply numbers.

Besides the records of the U. S. Geological Survey, the U. S. Weather Bureau issues annual reports of river stages at gage stations on the principal rivers of the United States, and miscellaneous data on the stages of rivers can also be found in the reports of the Chief of Engineers of the U. S. War Department on the improvement of certain rivers for navigation. The chief of engineers' reports are fully indexed in special volumes. The reports of the Mississippi River Commission and the Missouri River Commission are also valuable.

In addition to the data on stream flow published by the Federal Government, some of the publications of the various States, such as the reports of State engineers and State geological surveys, give similar information. A number of the State geological surveys have issued valuable monographs on water powers.

STATE REPORTS

The data given in State engineer and State geological survey reports are for the most part identical with what may be found in the Water-Supply Papers of the U. S. Geological Survey, as a large part of the Federal Government work is done in collaboration with the work of the individual States. This fact is almost always noted in State reports which give stream-flow data. The value of State reports is principally in the fact that they collect and edit, in one volume, data scattered in a number of the U. S. Geological Survey Water-Supply Papers, occasionally making additions of material not found in those papers.

Specific examples of state reports giving stream-flow data are those of the State engineers of Colorado and Montana, that of the Virginia Geological Survey on the hydrography of Virginia, and those on the water powers of North Carolina and Georgia, published by the geological surveys of these respective States. The reports of the various State geological surveys can be obtained at a small price or free upon request, and the printed lists of publications for sale or free distribution can be obtained from their respective offices. Reports of stream-flow data may also be found in a number of other reports, as:

Illinois Internal Improvement Commission—Surface Water Supply of Illinois, 1908-1910.

Minnesota State Drainage Commission—Report of Water Resources Investigation of Minnesota, 1909-1912.

Reports of the New York State Water Supply Commission, recently transferred to the Division of Inland Waters of the New York Conservation Commission.

Report of the Flood Commission of Pittsburgh.

It is evident, therefore, that a large amount of valuable data on stream flow is scattered in a variety of volumes, but the most comprehensive records are found in the U. S. Geological Survey Water-Supply Papers.

INDEX TO FEDERAL REPORTS

A printed index to a portion of the stream-flow records appearing in this series of publications is found in Water Supply Paper 119, entitled "An Index to the Hydrographic Reports of the U. S. Geological Survey, 1888 to 1903." An examination of this index shows an admirable alphabetical arrangement of the names of individual rivers with the index reference to any publication of the Survey, as Annual Reports, Bulletins or Water-Supply Papers, in which references to the stream flow can be found. Unfortunately this index has not been supplemented, and according to a recent statement of the U. S. Geological Survey office there is no plan at present to continue it on similar lines, so that the extension of this index must be done personally by those who make constant use of the records.

Another index, issued by the Survey on a different plan, has been published as Water Supply Paper 280 under the title "Gaging Stations Maintained by the U. S. Geological Survey, 1888-1910." This publication lists, under the headings of the twelve main drainage divisions, the names of rivers on which gaging stations have been maintained, with inclusive dates. At the end of the volume is an alphabetical index by which names of rivers can be located under their various drainage basins. This index is useful because it gives in tabulated form the dates of the establishment of the gaging stations on individual rivers, but it does not supply information as to the exact numbers of the Water-Supply Papers in which the annual records of individual rivers can be found. The omission of this information is important, as an examination of the set of publications known as the Water Supply Papers will show that these papers are consecutively numbered in the order of their publication so that the papers devoted to stream measurement records for various years do not have consecutive numbers. In addition to this difficulty the drainage basin of a river, according to the twelve drainage divisions adopted by the U. S. Geological Survey, must be known in order to locate the exact paper in which the record of a river for any specific year can be found.

In considering a plan for indexing these scattered stream-flow data it is obvious that it would be impossible for an engineer or even for a library, busy with many other duties, to continue the style of the index found in Water Supply Paper 119, that is, to make index entries under the names of every individual river. The following scheme of indexing, therefore, was adopted by one engineering library and has been found to give quick and accurate location of any stream flow record desired.

INDEX PLAN FOR QUICK REFERENCE

In devising this plan of indexing the point of view of the busy engineer who desires the information was primarily considered. He wants all the stream-flow records of an individual river for a consecutive number of years at a given geographical point. Therefore the most important item in indexing for quick reference was to show the number of the Water-Supply Paper in which the record for rivers in a certain State for a certain year appeared, There was adopted a system of tabulating the stream-flow data by States and year as they appeared in each Water-Supply Paper, and these records were put on cards in the library card catalog according to the following sample:

SAMPLE LIBRARY CATALOG CARD

627.0973		Stream Measurements—Montana
Un3	U.S.	—Geological survey—Water supply papers
	1903	—No. 99, 100
	1904	—No. 130, 135
	1905	—No. 171, 172
	1906	—No. 207, 208, 214
	1907–08	—No. 246, 252
	1909	—No. 265, 266, 272
	1910	—No. 285, 286, 292
	1911	—No. 305

The cards for each State are, of course, alphabeted according to the State names. An illustration of the rapidity of this method for finding stream-flow data follows:

FINDING THE DATA

It is taken for granted that the set of Water Supply Papers are all together on a shelf arranged according to the consecutive numbers under which they are issued. The engineer has an investigation to make upon the water power possibilities of the Missouri River near Townsend, Mont., and wishes all the available stream-flow records at this point for all the recorded years. He turns first to the index in Water Supply Paper 119, which is kept on the shelf either at the beginning or the end of the set of papers, and looks under "Missouri River" in this printed index and gets the numbers of the Water-Supply Papers in which records appeared up to 1903. He then turns to his card catalog under "Stream Measurements—Montana" and finds that stream-flow records for rivers in Montana are to be found for the succeeding years in certain numbers of the Water Supply Papers as shown on the foregoing sample card. He takes off the shelf the papers bearing these numbers and uses the alphabetical index of the names of rivers to be found in each of these papers covering stream flow in the State of Montana, and thus readily locates all the information about the Missouri River.

By the use of this system of indexing the complete records of the river in which he is interested are in his hands in less than ten minutes, whereas if he has no index under the State names he must first locate the watershed of the river and then locate the volumes containing that particular watershed for each year, which, as has been stated before, are widely separated by the numerical arrangement under which the Water-Supply Papers are published. This method of indexing has been thoroughly tried out by four years' use in the library of an engineering firm doing a large amount of water power investigation, and has proved most adequate in bringing quickly to hand all the desired stream-flow data published in the Water Supply Papers.

Following out this card index plan of using the heading "Stream Measurements" with subdivisions under the names of the various States, any publication containing stream flow can be card cataloged under these headings and the cards filed directly behind the index cards to the Water-Supply Papers, thus bringing together in the card catalog references to all the volumes in the library in which stream-flow records of rivers in any State have been published.

RAINFALL STATISTICS

As no irrigation or water power investigation can be conducted on the basis of stream flow, independent of a study of the rainfall of a region, it may be helpful to mention some useful collections of rainfall data arranged for ready reference.

The "Monthly Weather Review," published by the U. S. Weather Bureau, is the well-known source of rainfall records. Up to the year 1909 the "Review" published an annual summary, giving the total figures of the yearly precipitations at all rain gage stations. Beginning with 1909 this annual summary was omitted, so that it became necessary to consult the twelve monthly records from which the total annual rainfall at any given point must be figured.

In order to meet the need of a convenient annual summary after the year 1909, it was found that by collecting each year the annual summaries of the various State sections of the Climatological Service of the Weather Bureau, published by the section directors, and binding them together alphabetically from Alabama to Wyoming, a much more valuable annual summary was available than the one which had been discontinued as a part of the "Monthly Weather Review."

It was also ascertained that the climatological division of the U. S. Weather Bureau had divided the United States into 106 climatological sections and had printed in a series of pamphlets bearing the number of each section a tabulation by month and year of the precipitation records at all rain gage stations, from the earliest readings to 1909 inclusive. A complete set of these 106 sections was obtained and bound together so that with this volume and the volumes of the annual summaries just described, extending from 1910 to date, a complete tabulated record of the rainfall reported at any given point was quickly available. These annual summaries do away with the necessity of examining the monthly numbers of the "Weather Review" except in cases where the daily records of precipitation are desired.

Placing Railroad Embankment from a Pontoon Bridge

IN the double-tracking and grade-revision program being carried out by the Chicago, Milwaukee & St. Paul Railway between Minneapolis and Aberdeen, S. Dak., a distance of about 288 miles, in addition to the reduction of grades the total amount of curvature is being reduced from 3404 deg. to 1821 deg., and the number of curves lowered from 188 to ninety-two, involving more than 10,000,000 cu. yd. of grading and about 70,000 cu. yd. of reinforced concrete. One of the features of this work was a fill across a lake about 1200 ft. wide, averaging from 30 to 40 ft. deep. The bed of the lake is a soft and seemingly bottomless muck, test piles driven to a depth of 120 ft. indicating no firmer material.

The contractor, the Cook Construction Company, of St. Paul, intending to make the fill from side-dump cars, built a trestle across the lake, using 90-ft. piles. When filling was begun the weight of material forced the trestle out of line, and in fact tore it to pieces in two or three places. New piles were driven with the same result, and this happened five or six times.

Two scows were then built, and 60-ft. timbers were provided for stringers to carry the construction track. The scows were so placed that one set of timbers spanned from the bank to the first scow and another set reached from scow to scow. The filling was dumped at the head of the bank, the empty cars being pushed ahead on the outer span. When the new embankment reached the scow the inner span and that scow were moved ahead. The scheme has worked very successfully.

A 100-TON STEAM TRAVELING CRANE for the Havre harbor works is described in "Engineering" of London. It was built by Cowans, Sheldon & Company, Ltd., of Carlisle, England. It is capable of lifting, carrying and slewing loads up to 100 tons at a radius of 39 ft. 4½ in., all the motions being worked by steam power, at the following speeds: Lifting 100 tons, 8.2 ft. per minute; lifting 40 tons, 20.5 ft. per minute; revolving 100 tons, 1 r.p.m.; traveling with 100 tons, 32.8 ft. per minute. The carriage is built up of steel plates and angles, and travels on eight center-flanged cast-steel wheels which run on rails 19 ft. 8¼ in. center to center. All motions are worked from one set of horizontal engines with two cylinders, steam being generated in a vertical boiler.

Financial Relation between City and Its Public Utility

Wisconsin Railroad Commission Defines Principles in Case Involving Rates of Municipally Owned Waterworks at Sparta

A PUBLIC-UTILITY plant owned by a city should be treated as an enterprise separate and distinct from the city itself. All its accounts should be kept accordingly. In every respect the plant should be deemed an independent agency.

This is the conclusion of the Railroad Commission of Wisconsin in a recent case involving the rates of a municipally owned water utility. Wisconsin is one of the few States in which public utilities owned by municipalities are regulated by the State commission in exactly the same manner as privately owned public utilities. In this case the city of Sparta applied to the commission for authority to increase and readjust its water rates. The case was decided Sept. 13, 1913.

UTILITY A SEPARATE ENTERPRISE

The opinion of the commission on the relations which should exist between the city and its own public utility is as follows:

The major part of the testimony given at the hearing concerns the financial relations existing between the city and the water department. The testimony indicated that the accounts affecting the water department as distinct from the city had not been kept in such a manner as to accurately show these relations. It appears to be the desire of the board of water commissioners and the city officials, however, to have the plant placed upon a business basis, independent of the other city departments, and to have the accounts kept in such manner that all transactions affecting the city will be clearly shown. That this should be done seems highly desirable. Even though a plant be municipally owned and operated, it appears to be good business policy to treat it as an enterprise separate and distinct from the municipality itself, and to have all accounts kept accordingly.

Such a policy, however, involves several important considerations. These are as follows: (1) The city must pay the utility at a reasonable rate for all service rendered the city. (2) The utility must pay the city a reasonable amount as taxes and as interest on the city equity in the property of the utility. (3) The city must provide all funds for capital expenditures, such as new extensions, retirement of bonds, etc.

PAYMENTS BY CITY

Most municipally owned utilities serve the community in two ways—first, by rendering service directly to the city as a unit for public purposes, as, for example, by providing water for fire protection and street sprinkling or by providing light for the illumination of streets and public buildings; and, second, by giving service to private consumers for private use. Each of these two classes of service should bear as nearly as possible the cost of rendering that service. The city should meet the costs of the first class of service by payments from the general funds of the city, and private consumers should be required to pay the cost of the second class of service. Private consumers should not, however, be compelled to bear any part of the cost of the service rendered the city except as they contribute as taxpayers to the general fund of the city.

The rule here set forth should generally be followed strictly, for the adoption of any other policy is likely to result in unjust discrimination in one or the other of two ways. If the city pays less than the cost of the service rendered to the city, private consumers will have to bear the difference between this cost and what the city pays in the form of higher rates and will thus be discriminated against in favor of the taxpayers of the city. If, on the other hand, private consumers are charged less than the cost of serving them, the discrimination will be in their favor as against the taxpayers of the city and the latter will be forced to make up the difference through the payment of higher taxes.

PAYMENTS BY UTILITY

If the plant has been built out of the general funds of the city, the city is an investor in the utility and is entitled to a reasonable rate of interest on the investment. The money in this case, being furnished out of the general funds of the city, was derived from local taxes. The investment of these funds in other lines would bring a return to the city in the form of interest and would consequently decrease the amount of taxes required to be levied by the amount of this interest. Interest is one of the elements in the cost of furnishing service. Unless the city is paid a reasonable amount for interest, the rates for private users will be lower than the actual cost of serving them, and taxes will have eventually to be increased to make up the deficit. This would result in discrimination against taxpayers in favor of private consumers. A reasonable amount should also be paid by the utility for taxes if discriminations in favor of private consumers are to be entirely eliminated.

CAPITAL EXPENDITURE

In adopting the policy of requiring the respective classes of consumers to pay as nearly as possible for the actual cost of service, a clear distinction must be drawn between expenditures made in furnishing such service and other expenditures. Although variations due to local conditions and demands in this respect may be recognized within reasonable limits, it appears that as a general rule consumers should contribute through rates only enough to cover the cost of furnishing the service. This would include operating expenses and a reasonable allowance for interest, taxes and depreciation. That this may be accomplished as nearly as possible, all other expenditures must be provided for out of the general fund of the city—thereby increasing city equity—or an additional burden will be placed upon the consumers of the utility.

New extensions and improvements to the extent that they add to the original value of the plant should be provided for directly from the general fund of the city. It often happens that new extensions are made by using the cash representing the offsetting assets for the depreciation reserve. In the case of a municipal utility, this would postpone the time when the amount so used would have to be provided by the city, either through taxation or a sale of bonds. The investment in this manner can be considered merely temporary, however, and when the time arrives when replacements are necessary and actual cash is needed for this purpose, the amount of cash required for such replacements must be provided by the city and the city equity increase proportionately. Unless this policy is observed, one of two conditions must follow: Cash on hand offsetting depreciation reserve cannot be used for new extensions; or when cash offsetting the depreciation reserve is used for new extensions, no funds will be available when replacements are necessary.

BONDS

In case bonds have been sold to secure funds for extensions, the retirement of the bonds would logically be cared for by the city, out of the general funds of the city. It appears, however, that all bonds outstanding which were sold for the purpose of financing the construction work of the plant should appear in the balance sheet of the utility. The manner in which they should be carried in the balance sheet would depend upon whether they were general city bonds or utility bonds. If they are utility bonds, the bonds themselves will appear as a liability of the plant. If they are general city bonds they are not a direct liability of the plant, but as the money obtained from their issue has been used for utility purposes, their value should appear as a portion of city equity, and should be so recorded on the balance sheet.

INTEREST AND OPERATING EXPENSES

The attitude of the commission is illustrated further in its discussion of the basis on which should be computed the amount of interest to be included in operating expenses. This discussion is as follows:

In considering the interest which the city is entitled to earn, the question arises whether this interest should be computed upon the entire amount of city equity in the property of the utility. The city equity of a municipal utility may be composed of several elements, including outstanding city bonds issued for utility purposes, cash transfers from the general funds of the city to the utility fund to cover capital expenditures, and that element resulting from the appreciation of the plant value and the reinvestment of profits from operation. The purpose of municipal ownership appears to be to furnish service to consumers at cost without inflicting unjust burdens on either the consumers of the service or the taxpayers. The execution of this purpose requires revenue sufficient to cover the operating expenses together with a reasonable amount for depreciation, taxes and interest on at least those elements of the city equity which result from the sale of bonds and from cash transfers from the general funds of the city for capital expenditures. Whether or not the element in city equity resulting from the appreciation of plant value and the reinvestment of profits from operation should also be included in the amount of city equity upon which interest is to be earned, is largely a matter of local policy and should be decided in the light of local conditions. If the city so desires, it appears that it should be allowed to earn on the entire amount of city equity.

Measuring Turbine Discharges with Salt Solutions

Chemical Analysis Gives Results Accurate within 0.1 Per Cent

By ABRAHAM STREIFF
Civil and Hydraulic Engineer, Jackson, Michigan

CHEMICAL analysis as a means of gaging fluid discharges was discussed for the first time by Th. Schoesing in the "Comptes Rendus de l'Académie des Sciences" in 1863, and has been mentioned or tried since then by Van Iterson, E. Lemaire, Ch. E. Stromeyer, Cote and Bellet. In 1910 A. Boucher, the designer of the power plant being built in Switzerland to operate under a head of a mile, tested with a salt solution the discharge of a turbine in the Day power plant at Vallorbe, but no comparisons with any other method of water measurement had been made to establish the degree of accuracy attainable by this method.

With the recent work of Dr. Leon W. Collet, director of the Swiss Hydrographic Bureau, this chemical method of water measurement has become more important and, as far as accuracy is concerned, it is comparable with the weir, current meter and moving screen. Dr. Collet measured turbine discharges at the Ackersand power plant, near Viege, Switzerland, by weir, current meter, moving screen and salt solution. The Ackersand plant is the only one in Switzerland equipped with a moving screen, and the square, straight tailrace offered ideal conditions for current meter measurements. At the end of the tailrace was a thin-edge weir with end contractions, so that comparisons of the four methods could be made.

Dr. Collet has published the results in a bulletin issued by the Swiss Hydrographic Bureau entitled "Gaging by Titration," from which the following notes are taken.

By injecting a certain amount of concentrated salt solution in either head or tailrace of a turbine the degree of dilution of the salt in the tailrace after a certain period of time permits the determination of the discharge of the turbine. This is due to the fact that the ratio of the discharge of initial solution to the discharge of the turbine varies inversely as their concentrations. Three conditions must be fulfilled to obtain accurate results: (1) Discharge of initial solution must be constant, (2) perfect mix, and (3) precise titration of the salt solutions.

CONSTANT DISCHARGE

It is easy to obtain a constant discharge by means of a large and a small barrel if the latter be provided with a surface control for constant head. The larger the difference in height between the spout distributing the solution and the level in the barrel the greater the accuracy. As a rule, this difference should be made a thousand times the allowance of surface fluctuations, if the results are to be accurate within 0.1 per cent.

The salt solution must be clear and free from impurities, which, by clogging the orifice, would introduce errors. It should be filtered before use. The discharge should be measured carefully at the beginning and end of the test. The amount of initial solution injected should be about 0.0001 of the approximate discharge of the turbine.

Accurate results require that there be a perfect mixture of the salt solution and the discharging water. Tests have shown that a perfect mix is easily obtained in a high-head turbine with comparatively small discharge. Under certain conditions the method also could be used for low-head turbines.

PRECISE TITRATION

A volumetric analysis of the salt solution can measure the discharge of a turbine with an accuracy of 0.1 per cent. In order to analyze the initial solution three solutions are needed—one of silver nitrate, one of salt, and one of potassium chromate. This chemical analysis is given in detail in the pamphlet referred to. N_1 is the number of cubic centimeters of silver-nitrate solution needed for titration of 1 liter initial solution; n, the number of cubic centimeters of silver-nitrate solution necessary for titration of 1 liter of turbine discharge before the test; N_2, the number of cubic centimeters of silver-nitrate solution needed for titration of 1 liter of turbine discharge during test; d, discharge of initial solution; and D, the discharge of the turbine in liters per second. This discharge is given by the formula

$$D = d[N_1/(N_2 - n)] - d \text{ liters per second.}$$

The net head on the turbines during the tests at the Ackersand power plant was about 2300 ft. Each unit develops 5500 hp at 500 r.p.m. The discharge of one turbine is about 26.5 sec.-ft. Two series of tests were made—by injecting the initial solution direct into the turbine and by discharging the initial solution into the tailrace.

RESULTS

The results are as follows:

(1) Initial solution discharged into the turbine:

	Salt solution	"Epper-Ott" current meter	Moving screen	Weir
D, liters per second..	1356.5	1317.5	1303	1339

(2) Initial solution discharged into the tailrace:

	Salt solution	"Epper-Ott" current meter	Moving screen	Weir
D, liters per second..	1305.2	1291	1299	1312

In the first test the discharge obtained by titration is somewhat too large on account of loss of the salt solution into the tailrace of other units, as was verified by fluorescein injections. The weir discharge was calculated by the Frese formula, which, contrary to Bazin's, includes end contractions, as the weir was a thin-edged weir with end contractions. The weir discharge is slightly erroneous on account of the influence of two iron bars fastened to the gate forming the weir. Nevertheless, the differences in the second test are well within 1 per cent of the average of all four measurements. This average is nearly equal to the discharge obtained by the moving screen.

It seems that with proper apparatus, gaging by titration can be applied with the same precision to the testing of low-head turbines with large discharges. The initial solution would have to be carried through tubes into the guide vanes of the wheel to insure proper mixing.

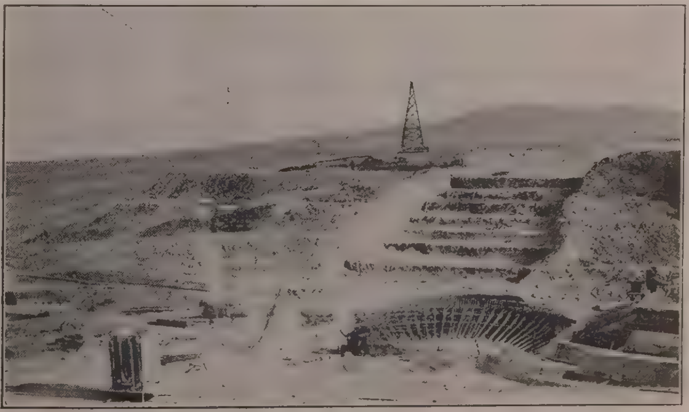
According to information received from Dr. Collet, tests have been made with perfect success at the power plant in Ventavon, France, by Messrs. Mellet and Boncher on Francis turbines having a discharge of 525 sec.-ft. Dr. Collet has gaged mountain streams having a discharge of 1000 sec.-ft. and believes the chemical method to be the only one capable of measuring discharges within 0.1 per cent.

Spillway Pool at Lahontan Dam

VIEWS are shown herewith of the spillway pool below the Lahontan dam of the Truckee ,Carson irrigation project of the U. S. Reclamation Service which is about 80 per cent completed. The pool is 220 ft. in diameter and has a depth of 30 ft. It is designed to retard the velocity of the water coming to it over a series of concrete steps from the concrete spillways at each end of the earth and gravel fill type described in the Engineering Record of May 18, 1912, page 553, where also is detailed the spillway pool. A comprehensive article on grouting the fissured foundation of the dam appeared on March 29, 1913.

Below the pool may be seen the 1000-kw construction hydroelectric power plant fed from the Truckee Canal and the overflow discharge from the forebay. One of the photographs indicates the method of handling the material by cableway. An electrically-operated dragline excavator and an electric power shovel were also used.

Circular Pool at Lahontan Dam Spillway



Excavation for Spillway and Forms for Pool Walls

Ties—Record-Keeping, Future Supply and Protection from Mechanical Destruction

Abstract of Three Papers Presented before Convention of American Wood Preservers' Association at New Orleans January 20-22

Protection of Ties from Mechanical Destruction

By HOWARD F. WEISS
Director, Forest Products Laboratory

IN 1907 the American Railway Engineering Association sent out letters asking various railroad engineers what percentage of their ties failed from decay and what percentage from mechanical destruction. The replies in general were that about 90 per cent of oak ties failed because of decay, as against 25 per cent of cedar. In other words, the mechanical destruction of the ties varied from a minimum of about 10 per cent for oak to a maximum of about 75 per cent for cedar. The good results secured by timber-treating engineers in protecting ties from decay are placing each year a larger per cent of ties in the cedar class insofar as their mechanical life is concerned. This means that the problem of mechanical protection is one of increasing importance. It is a waste of preservative, effort and money to inject into ties an amount of preservative which will protect ties beyond their mechanical life, because after the tie has once failed mechanically it is removed from the track and destroyed.

Tie Plates

Rail wear is minimized by means of tieplates, which protect the tie from the crushing and pounding action of the rail due to the passage of rolling stock, and from the grinding action of the rail caused by its tendency to creep and vibrate.

Wood plates are used rather extensively abroad, and are also under test in this country. The results have not thus far been satisfactory. Wood plates offer little or no reinforcement to spikes when these are subjected to a lateral thrust; consequently the spikes are more likely to bend and rail spreading is more likely to occur. Furthermore, the plates often tend to work loose from under the rail and if spikes are driven through them they split badly. In some of the tests the wood plates actually became imbedded in the ties. If the tie is slotted so that the plate can be inserted in such a manner that its upper surface will be level with the top of the tie many of these objections are overcome, but this method of treatment increases the cost of preparing ties for service, and also weakens them.

More satisfactory results have thus far been secured with metal plates. These may be classed into two types, viz., pronged or ridged plates and flat plates. The chief disadvantage in the former class is its tendency to gouge into the wood and at times completely destroy it. The untreated interior of the tie is thus exposed to the weather and decay is readily admitted. Flat plates do not have this objection, but are troublesome at times in that they become loose and rattle under the rail. Furthermore, they simply rest upon the tie and offer no reinforcement to the spike against lateral thrust.

A feature in tieplate construction which has perhaps not been given the serious attention to which it is entitled is the size of plate for the kind of tie on which it is to be placed. It is necessary to have the plate of sufficient surface area so that the crushing action of the rail will be distributed as widely as possible, and to have sufficient thickness, so that no buckling will occur. The various woods which are now manufactured into cross-ties differ very appreciably in hardness and in crushing strength. That track is best laid which makes each tie carry its proportionate share of a passing load; therefore, to secure best result, tieplates should be so designed that the unit loads placed on various kinds of ties will be approximately the same. Perhaps best results are secured by placing in the track ties of uniform hardness at least in given stretches.

Spikes

Spikes must exert a resistance to pull and resistance to lateral thrust, the former resulting from the so-called "bumping" of the rail, the latter accentuated by the centrifugal force exerted by the train in rounding curves. The cut spike is by far the one most generally employed in this country. It is cheap, enables a quick laying of the rail and is easily applied. When freshly driven in sound, heavy timber it also gives very satisfactory results. It frequently becomes loose in ties, however, and under such condition may cause an unsafe track.

The screw spike has been most successful thus far in removing the chief criticism leveled against the cut spike, viz., its low holding power. Screw spikes are more costly than cut spikes and more difficult to insert in the track. In numerous tests made at Purdue University, a part of which were conducted by the Forest Service, it was found that screw spikes had from 1.7 to 3.8 times the strength of common cut spikes against pull, and from 1.2 to 2.4 times the lateral resistance of the common spike. In round numbers one screw spike is about as efficient as two cut spikes so far as holding the rail to the tie is concerned.

The large number of ties cut from comparatively soft woods, such as loblolly pine, has encouraged certain roads to experiment with hardwood dowels. These are simply plugs of hard wood, such as red oak, usually creosoted, screwed into the tie. The spike is then driven or screwed into this hardwood dowel. By this method a very firm grasp of the rail to the tie is secured, and should the spike become loose and worn, the hardwood dowel can be unscrewed from the tie and a new one inserted. Such a method of treatment is expensive, and has the disadvantage that it weakens the tie unless the ballast is kept in very good condition. Where it has been put to practical test, however, it has yielded very satisfactory results.

Adzing and Boring Ties

As by far the larger number of crossties now in use are hewed, the problem of securing a uniform bearing of the rail or tieplate on the tie is of great importance. Unfortunately, common practice in this country consists in adzing such ties after they have been treated. This removes the preserved layer of wood at the very point where its protection is most needed. It is essential to have the rail or tieplate bear uniformly on the tie and unless the ties are adzed this result is rarely accomplished. Adzing is, therefore, strongly recommended, particularly on hewed ties. The proper time to adz, however, is before and not after the ties are treated.

Another feature in too limited use at present is the boring of the ties for the insertion of spikes. When screw spikes are used it is necessary to bore a hole into the tie in order to insert them, and if this hole is bored after the tie is treated the unprotected interior is more or less exposed to decay. Boring should, therefore, be done before the ties are treated. Even with the ordinary cut spike, boring is of direct value.

Conclusions

The following general conclusions can be drawn:

(1) The increasing number of treated ties being used is increasing the importance of protecting them from mechanical destruction because the problem of protection from decay is being rapidly solved. To secure best results, therefore, a protection of treated ties from rail and spike cutting is strongly recommended.

(2) Soft ties demand a larger plate than hard ties. It is felt that this fact should be recognized in fixing upon the price of various timbers for cross ties.

(3) Preservative treatments with creosote and zinc chloride when properly made scarcely affect the crushing strength of ties.

(4) On account of their holding power screw spikes are preferred to cut spikes and can be recommended where high-class construction is desired.

(5) Adzing and boring ties, particularly the adzing of hewed ties, prior to treatment, are of prime importance in preparing them for service.

Methods of Keeping Tie Records

By E. T. HOWSON
Engineering Editor, "Railway Age Gazette"

IT is highly important that the responsible officers in charge of the selection, separation and use of ties know the essential details of the work and realize the opportunities for economy or waste. They are called upon to decide upon the relative merits of the different kinds of wood, the advisability of treatment, the extent to which timber should be treated and the processes best suited for the widely varying densities of traffic, climatic conditions, etc., existing on the different divisions. While without question sufficient ties can be secured to meet the demands of any line without a great knowledge of their relative durability for the particular service, the probabilities are slight that the best selection will be made without previous careful study.

In studying the relative economy of various kinds of ties, a knowledge of their service under the conditions to which they are to be subjected is as essential as data regarding their first cost, and these conditions vary widely on different portions of the same system. The extent to which ties are to be protected from decay as compared with mechanical wear on different portions of the same road is obviously not the same. Likewise, the tie possessing the longest life under certain conditions is not necessarily the most economical. Soft woods obtained near by and properly treated may be cheaper in the ultimate analysis than more expensive ones possessing a longer life. Again, with the rapid depletion of the forests and the continual restricting of the limits of good tie timber, conditions are changing and the most economical tie to-day will not necessarily be the most economical in a few years.

METHODS OF SECURING RECORDS

The methods of determining the life of ties are now passing through a rapid process of development. The first and simplest method, dividing the total number of ties in the track by the number inserted in a year, gives only general averages and furnishes no information concerning the relative values of different species of wood or the effects of local roadbed and other conditions.

With the increase in the use of treated ties the demand arose for more accurate information concerning the merits of the different treatments. To furnish this information, a number of roads mark each tie, or at least each treated tie, with some distinct symbol indicating the year it was installed. Theoretically this provides a record of every individual tie under the actual conditions to which it is subjected. Practically, however, it has been necessary to rely upon records prepared by the section foremen who place and remove these ties from the track and it has been found impossible to secure accurate records from the large number of foremen employed.

TEST SECTIONS

Due to the difficulty in securing accurate records of all ties from the average section foremen it is becoming generally realized that a more accurate system of collecting data is necessary. The Burlington and the Santa Fé were the first to use test sections with ties properly marked and inspected at regular intervals by competent men.

In 1910 the Santa Fé selected one section on each operating division and took a careful inventory of every tie under both main and side tracks, determining, wherever possible, the year each tie was put in. Since that time a monthly report of all ties renewed has been made and an inspector from the timber-treating department examines all ties removed from each test section every three months. In addition this inspector makes a close annual inspection of all ties in these special sections. In this way the character and condition of the ties taken out can be observed, and more important, all ties inserted are properly marked. Due to the large number of unmarked ties which were left undisturbed in these sections when the records were started, it will be some time before full information will be available, but if this record is continued there is no reason why it should not be entirely accurate.

BURLINGTON METHOD

The Burlington began installing test sections in 1909. It was at first intended to install one special test of 1000 ties on each of the nineteen operating divisions, but this has since been extended until as many as two or three tests have been installed on some divisions and 26,000 ties are now under special observation. Differing from the Santa Fé plan, the ties are either renewed to face in an old track to present a continuous stretch of ties of the same age, or where possible, advantage is taken of the construction of new track to place these test sections where it will not be necessary to remove the old ties. In this way each tie, at least at first, carries its full share of the load and all ties are placed upon an equal basis. The limits of these test sections are carefully marked by posts bearing brass plates giving general data regarding the tests.

Two different nails are placed in the upper face of each tie about 34 in. from one end. The first letters of the alphabet are used to denote the species of wood, while the kind of treatment is denoted by one of the last letters of the alphabet. Thus a tie marked "FY" is creosoted soft maple. As the ties are installed they are numbered consecutively in white paint on the ends for comparison with blueprints showing the characteristics of the ties in their proper order.

These ties are renewed only under the supervision of the roadmaster, except in cases of emergency, when the foreman makes a complete report. An annual inspection of each of these test sections is made by the superintendent of timber preservation personally, accompanied by the division superintendent, roadmaster and section foreman. This inspection is made in August and September when the fungus growth is most evident and when the weather permits of close inspection.

SUGGESTIONS

In making preparations for such test sections, special care should be taken to secure No. 1 ties in all cases, as a few inferior ties may vitiate the entire results. Likewise, in selecting locations for tests great care should be taken to secure as representative and at the same time as varied conditions as possible to cover thoroughly conditions existing over the system. While not essential, it is of considerable advantage to place 100 ties of each kind together so that records are at once available in terms of percentages, and at the same time no one set of ties is required to carry a portion of the load of ties of another kind which may fail early. Where only three or four ties of a kind are placed together their life may be shortened by the failure of ties beside them throwing an undue load upon them. Also, a larger number of ties of each kind will give more accurate results than where only two or three are placed together, for the premature failure of one will seriously affect any results computed upon a percentage basis. The first cost of installing a test section in operated track is, of course, greater where all ties are placed together, as on the Burlington, than where the ties are spotted as on the Santa Fé. However, this first cost of installation is almost the only additional cost, as the inspection can be taken care of ordinarily by the inspectors regularly employed at the treating plants.

Future Supply of Tie Material in the United States

By H. H. GIBSON
Editor of "Hardwood Record," Chicago

THE building of new railroad lines is not at an end, and if it were so, the call for ties would not greatly diminish, because the principal demand is for repair work. In round numbers 125,000,000 cross ties are needed yearly. Practically the entire quantity is cut from nine or ten kinds of wood, namely, oak, pine, Douglas fir, cedar, chestnut, cypress, tamarack, hemlock and redwood.

Oak and pine constitute 65 per cent of all ties used in 1911. The largest demand is made on oak, because it has been regarded as the best tie wood, all things considered; and the first indications of diminishing supply are seen there. The railroads can still buy all the oak ties they want if they are willing to pay the price; but the contractors are obliged to go farther to get them, to take a little lower class of trees and to charge more for the ties. In the country as a whole oak, especially white oak, is being cut much faster than it is growing, and it is only a matter of time until scarcity will be everywhere felt. Most ties are cut from small trees, and this practice strikes the oak supply of the future in a vital spot; for a tree that will make three or four ties now would be good for as many saw-logs some years hence. The oak-tie cutters, therefore, are industrious destroyers of prospective forests.

THE PINES

The second important cross-tie source is pine. The four Southern yellow pines are considered best in the pine class, and long-leaf pine, being harder and more durable than the others, is at the head of its class. This is the tree commonly known as Georgia pine, hard pine and heart pine. Two other Southern yellow pines are largely cut for ties, short-leaf and loblolly. They are softer than long-leaf pine and decay more quickly when exposed to the weather. Long-leaf pine grows slowly and reproduces poorly. When present forests are cut little more need be expected from that tree. The situation is much the same with short-leaf pine.

It is thus seen that white oak and Southern yellow pine, which are at present the chief sources of ties, are being depleted. The process is not so rapid as to call for immediate alarm, but the tendency is unmistakable. Much Northern white cedar remains, but its growth does not half make good the cut, and any increased demand would quickly bear results in lessened supply. The same holds for hemlock and tamarack. Chestnut is a substantial tie material, but it is now passing through a crisis on account of the blight, and no dependence for the future can be placed in it.

To sum up, the trees which now furnish the bulk of ties, and have done so for years, cannot do so much longer. Ties, however, must be had, and new sources of supply must be found.

Douglas fir, Western yellow pine and redwood are abundant in the far West. They are supplying about 16,000,000 ties a year now, and for years to come they could furnish all the railroads of the United States. In fact, there is enough of these three woods on the stump now to supply for 200 years all the ties wanted, provided the demand did not increase above what it is now. The wood is needed for other purposes, however, and is so far away from the majority of the railroads that the cost of the 2000 or 3000-mile haul would be prohibitive. The railroads must find ties closer home as long as possible.

New Methods Needed

As far as absolute scarcity of tie timber is concerned, it will be many a year before railroads are unable to get some kind of ties if they are able and willing to pay the price; but the time is not far off when the manner of providing ties for the country's railroads will need radical revision. The revision has already begun, and its basic principle does not consist so much in searching for new woods as in treating with preservatives the old woods to make them last longer.

The search for new woods has nevertheless been thorough. Enthusiasts have suggested that the semi-tropical hardwoods in southern Texas and Florida be utilized for cross ties. The hardness of the woods and their unquestioned durability have been pointed out. The suggestion is made without due consideration of the fact that the ties are a long distance from the places where they are needed. Furthermore, while the list of alleged semi-tropical tie timbers includes mangrove, lignumvitae, blackwood, strongback, buttonwood, inkwood, mesquite, huisache, catsclaw, horsebean, Texas ebony and fifty more, the names are about all there is of the trees. Trunks are few, small, crooked, branched and deformed. Railroads in the immediate vicinity use some of the woods for ties, but it is because they are convenient.

Conservation by Preservation

Efforts to plant trees and grow the necessary timber have not been successful. The reasonable thing to do is to treat all cross ties with preservatives to make them last longer. By doing that the demand can be cut down nearly one-half, because a properly treated tie lasts nearly twice as long as one in its natural state. In that direction lies the hope of the situation. Ties can be made of timbers heretofore regarded as scarcely worth cutting for that purpose. Practically every tree that grows in this country, if large enough, is good for ties, if treated. If very soft, like buckeye, aspen and white pine, plates can be used under the rails to prevent rapid wear.

Viewed in that light, the tie situation is not particularly discouraging. Some of the old tried woods are becoming scarce, but dozens of others heretofore hardly used are available with the aid of the treating tank. A practically clean sweep can be made of all trees on a tract, provided they are of suitable size. That will bring ties to the tracks which heretofore were left as an encumbrance on cutover land. Utilization will be closer, waste will be less. It will not be a question of finding new sources of tie material, but of making better use of well-known sources.

Skylights in Jersey City Trainshed

Lighting Area of 95,500 Square Feet of Reinforced Glass Is Provided in New Terminal of the Central Railroad of New Jersey

DAYLIGHT illumination of the new trainshed for the Jersey City terminal of the Central Railroad of New Jersey, which is covered by a large concrete-slab roof supported on short-span steel girders, is provided for by raised skylights covering 31 per cent of the total area of the roof. The skylights are arranged in long, narrow frames directly over the passenger platforms and parallel to the tracks. They are easily accessible for repairs and cleaning, are elevated above the general roof surface on curbs clear of drainage and obstructions and are made of heavy reinforced glass with steel frames. Special metal sheeting and flashing are designed to make them thoroughly watertight. They cover a total area of about 95,500 square feet.

Arrangement and Construction

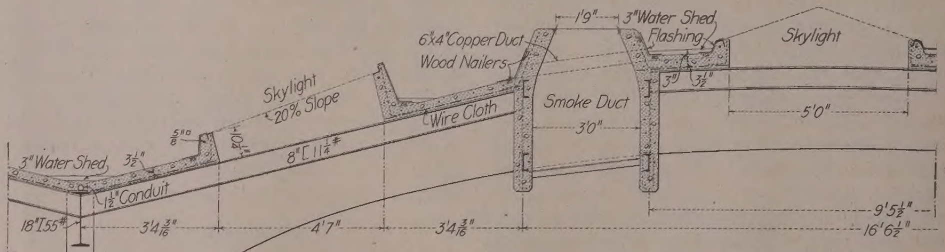
The trainshed, which was described in the Engineering Record of Jan. 4, 1913, page 6, is of the Bush patent type, with nine parallel roof spans of 39 to 43 ft. Each span is pitched from the center to both ends, where it drains to longitudinal gutters with down spouts at interior columns. Each span covers two tracks and is supported on columns on the center lines of the platforms between the pairs of tracks under adjacent spans. The skylights are arranged at the center and both ends of each span, so that there are two skylights over each platform and one skylight over the center line between each pair of tracks. The skylights, approximately 5 ft. wide, are both hipped and single pitch, and are made in panels 24 ft. long separated by 3-ft. spaces for passageways and drainage. They are set on curbs cast integral with the roof concrete and elevating them several inches above the general surface. They are glazed with heavy sheets of solid rolled ribbed wire glass 10 in. wide, long enough to extend across the full width of the slope and secured by interlocked pressed metal strips attached to the structural steel framework. Continuous longitudinal open smoke ducts parallel with the skylights and intermediate between them discharge the smoke and locomotive gases above the skylights and provide sufficient ventilation, so that all of the skylight construction is fixed.

Glazing

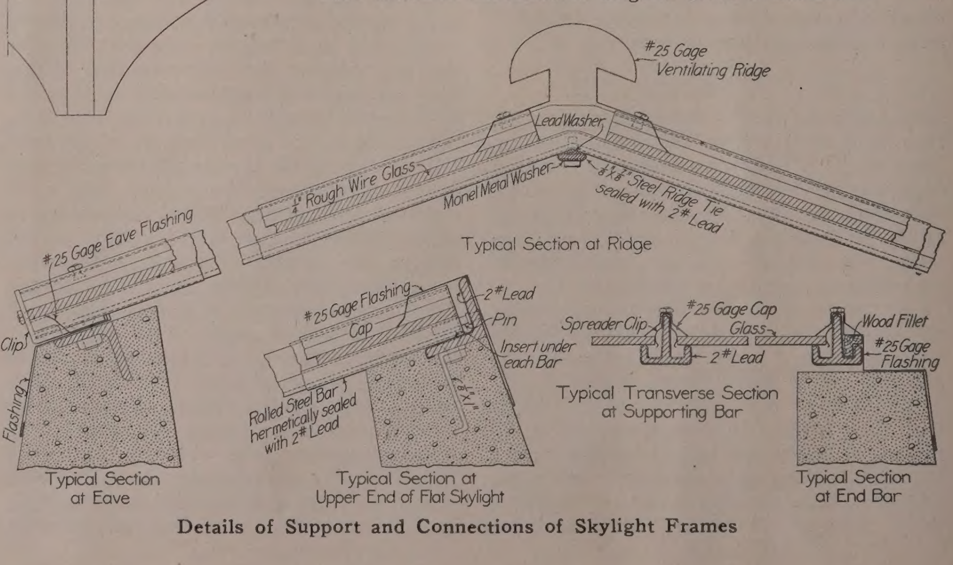
The sheets of glass are supported on 1½ x 1½ x ¼ in. guttered T-bars transverse to the axis of the skylight, placed 20¾ in. apart and pitched 20 deg. to the horizontal. For the flat skylights the bars are straight; for the hip skylights they are bent at the center and are run continuous across both slopes. The lower ends rest on right-angle clips bolted to continuous longitudinal bearing angles embedded in the concrete curbs, and prevent the T-bars and glass from slipping downward. Between the T-bar and the curb there are bolted two longitudinal pressed metal flashing strips, one of them bent upward to continuous contact with the glass and the other bent downward to form a casing covering the top and outer face of the curb.

Clips are omitted at the upper ends of the T-bars, which are seated on longitudinal bearing angles and are covered with continuous pressed-metal flashing strips that engage the upper surface of the glass and the face of the curb. The upper surface of this bearing angle and all surfaces of the T-bars are covered with 2-lb. lead.

The glass is supported directly on the T-bars, and the edges of the sheet engage



Part Sectional Elevation of Regular Roof Construction



Details of Support and Connections of Skylight Frames the convex surfaces of pressed-metal spacing strips which cover the vertical webs of the T-bars. The joints are covered by pressed-metal spring flashing strips bolted to the T-bars and exerting a positive pressure on the upper surface of the glass. The center points of the T-bars in the hipped skylights are connected by continuous longitudinal horizontal bars inclosed with 2-lb. lead, and bolted to them against lead washers. The 3-in. space between the upper ends of the sheets of glass in the hipped skylight is covered by a continuous longitudinal pressed metal ventilating ridge bolted to the T-bars and having the lower edges in contact with the upper surface of the glass. Except for the T-bars, bearing angles, and lead covering, all of the metal used in the skylights, including the flashing, is Monel metal.

The work was designed and constructed under the direction of the engineering department of the Central Railroad of New Jersey, of which Mr. J. O. Osgood is chief engineer and Mr. J. J. Yates engineer of bridges. R. P. & J. H. Staats were the contractors, and the skylights were made by the National Ventilating Company, of New York.

Book Reviews

"Coal Washing in Illinois" is the title of Bulletin 69 of the Engineering Experiment Station at the University of Illinois. The booklet is by F. C. Lincoln, assistant professor of mining engineering at the university. It contains 108 pages, 25 illustrations and 22 tables. Several introductory sections precede the discussion of coal-washing methods, results and costs, to which 47 pages are devoted. The last 40 pages contain various appendices, which include a bibliography, a chronology and statistical data. (Urbana, Ill., University of Illinois. 50 cents.)

Oil Production Methods. By Paul M. Paine and B. K. Stroud, with a chapter on Accounting Systems by W. F. and W. B. Sampson. Cloth, 6 x 9 in.; 240 pages; 216 illustrations. San Francisco, Western Engineering Publishing Company. $3 postpaid.

This book, as the authors state in the preface, covers problems associated with the production of petroleum which lie in that middle ground where the geologist, engineer and driller meet. The latter class, perhaps, will find in this book little that is new, but it contains material of value to the geologist and engineer—especially the recent graduate. The methods described are for the most part those used on the Pacific Coast, but the authors believe that these methods are the most advanced. The book is divided into the following chapters: Geology, rigs and equipment, drilling methods, exclusion of water from oil sands, production, fishing tools and methods. The last chapter, written by Messrs. W. F. and W. B. Sampson, describes comprehensively accounting systems and reports.

Descriptions of Land. By R. W. Cautley, Late Surveyor to the Land Titles Office at Edmonton, Alberta, and Member Alberta and British Columbia Boundary Commission. Cloth, 5 x 7½ in.; 89 pages. New York, The Macmillan Company, $1.00 net.

This book has been written primarily as a text book for students of surveying in Canada who are required to pass an examination in the subject, and also as an introduction to this important though somewhat neglected part of the land-surveyor's work. By means of an unusually lucid and concise style the author has been able to compress a good many thoughts in a comparatively few pages. The underlying principles of correct land descriptions are stated, and the reasons for certain forms and usages fully but briefly discussed. The last third of the book is devoted to examples of typical descriptions, both good and bad, with the flaws and perfections of each properly pointed out. The arrangement of subdivisions is logical, and a system of marginal summaries of important paragraphs adds much to facility of reference. Young surveyors, both in Canada and the United States, will find in this book many suggestions of value from an experienced surveyor and able writer.

Mechanical Refrigeration. By H. J. Macintire, Assistant Professor of Mechanical Engineering, University of Washington. Cloth, 6¼ x 9½ in.; 346 pages; 121 illustrations. New York, John Wiley & Sons, Inc. $4 net.

(Reviewed by William W. Bird, Professor of Mechanical Engineering, Worcester Polytechnic Institute)

The author starts with the supposition that the reader is familiar with mechanical refrigeration, and so only a few representative types of machines are described, and only a hasty review is given of the more important equations and heat cycles. In addition to the above-mentioned subjects, consideration is given to auxiliaries, theory of mechanical refrigeration, refrigerating mediums, testing, insulation (including the construction of buildings), economy and specifications, applications (including ice making), cold storage and cooling of air, liquids and solids. The heat changes in the absorption machine are more fully treated than in most books, and special attention is given to the properties of the refrigerants, especially those of ammonia, with tables and charts. These are based on the work of Wobsa, Mollier, Ferguson and others.

The book, which is intended for technical students and engineers, is well written, with clear and direct explanations and is well adapted to the use of either class, although there are some parts that would not be understood by the engineer who did not have some knowledge of the principles of thermodynamics.

Compressed-Air Practice. By Frank Richards. Cloth, 6¼ x 9 in.; 326 pages; 96 illustrations. New York, McGraw-Hill Book Company, Inc. $3 net.

This book is in effect an acknowledgment by the author of the wonderful advance in the use of compressed air since the publication some twenty years ago of a treatise by himself on a similar subject. In the opinion of the author the extended production and various uses of compressed air are of such importance as to warrant a careful discussion of them in text-book form. While there is, of course, in many instances an opportunity for analysis by theory, for the most part the operation of mechanisms making and using compressed air is distinctly empirical and the application of formulæ is to a large extent based on commercial considerations.

In detail there are twenty-eight chapters, taking up in order the principles underlying the production of compressed air, the devices for producing it, the distribution, the various uses to which it is put and miscellaneous matters such as tables for use in design and other problems. For the most part the questions relate to air under considerable pressure. Little space is given to anything pertaining to fans, blowers, or similar devices, and while this may be somewhat disappointing to the average student or engineer it can in no way be considered a fault of the author, since such information is not intended to have a place in this book.

Viewed broadly, the method of treatment, together with the nature of the information, makes this book of great value to the engineer as well as the student interested in this particular field, and to such it is strongly recommended.

Letters to the Editor

Raising Standard of Engineers in Pacific Northwest

SIR: A movement toward the establishment of constructive competition and the elimination of destructive competition in the field of engineering has recently been started by a few of the engineers of the Pacific Northwest. Growing out of a nucleus of about a dozen civil engineers and surveyors of Seattle, who affiliated less than two years ago under the name of the Washington Association of Engineers, the movement has spread, until to-day it numbers on its rolls not only civil engineers and surveyors but also consulting, mining, mechanical and electrical engineers. The association contemplates the establishment of branches in all the cities of Washington, and is at present working toward that end.

The rapid growth of the Northwest, and particularly of Seattle and its environs, has naturally attracted many engineers of all kinds and conditions—including those entirely unfit, who bring discredit to the profession by their unprofessional conduct and inferior ability. The purpose of the association is to eliminate such from the field, thereby protecting the reputable engineer, and at the same time the client in a way which is thought to have marked advantages over any system of State or municipal licensing that could be devised, inasmuch as it is wholly under the control of the engineer, who is, perhaps, the best judge of the necessary qualifications for practising in that honored profession.

Realizing that merit and ability should be recognized with adequate reward, the association first formulated certain limitations or requirements for membership and then set about to establish through committees of experienced engineers a "schedule of minimum charges" for each branch of the profession represented in its membership. These schedules are revised from time to time to meet changing conditions.

This radical departure from the usual "schedule of fees" adopted by various bodies of consulting engineers is in line with the progressive spirit of the great Northwest, and although at first thought it smacks of trade unionism, it is not at all on that order, but is more like the minimum-wage laws. There is absolutely nothing to prevent an individual engineer charging as high a fee as he feels his services are worth. The sole purpose of the schedules is to eliminate the cut-throat practice of underbidding. No member of the association will bid under these minimum rates, and in this way is aborted the common practice of clients giving an engineer a competitor's figure and inviting him to underbid. And not only that, but where it is known that one engineer has been approached by a client, the others will refuse to try to secure the job themselves without first consulting with the other engineer. All this is in line with the "code of ethics" drafted by the association, which was probably the first of such codes to be drafted by any engineering society in the Northwest.

The primary purpose of the association would fall flat if measures were not taken to eliminate the unprofessional practitioner absolutely from the field. A standing committee was therefore appointed for the investigation of cases of this character and to make a report of them to the association, which in turn takes immediate steps to rectify the evils by personal conference with the engineer and his clients, or by legislation, or in other ways. The old method of underbidding was rapidly destroying the reputation of the engineering profession as a whole in this section, as it often threw the work into the hands of those who were incompetent or inexperienced, or of those who had to slight the work because of the low figure at which it was taken. The new way insures much better service to the client, as the engineer is allowed sufficient time in which to study the problem more carefully, and it accords adequate reward for his services.

It will take time to educate the clientele up to the value of the new order of things; but it is of record that many clients have already recognized the advantages of paying a little more and getting vastly better results. Already the healthy effect it has had is being felt among the engineers. The "scamps" are closing their shops, while many good men, who were formerly forced to do their work for almost nothing, are now not only getting pay more nearly commensurate with their services, but are able to pay better wages to the men under them.

Realizing the advantages to be gained by membership in the association, the engineers of Seattle are rapidly becoming affiliated, and in other cities of the State an interest is awakening in the movement toward the establishment of local branches. It is anticipated that before the end of this year all engineers in Seattle and its vicinity who are interested in elevating the standards of their profession will become members, and that several local branches will have been started in other cities.

It is only through the co-ordinate action of all the reputable engineers that the general public can be brought to a realization that the best is the cheapest in the long run. It is only through such co-ordinate effort that the public can be made to realize what this means, especially in this profession, where the expenditure of vast amounts of public and private funds depends upon the judgment and knowledge of the engineer.

The association meets monthly to discuss local questions, the standardization of office and field methods, and other matters of general interest to its members. The officers for the current year are: J. Thomas Dovey, president; Clarence L. White, vice-president, and Stirling B. Hill, secretary-treasurer.

H. F. TUCKER,
Seattle. Consulting Engineer.

A Problem for Young Engineers

SIR: There have been unrest and open expression of dissatisfaction among the younger engineers and recent technical graduates. The claim is made that they do not receive a sufficiently just reward for their services in comparison with those higher up in the profession. Out of this dissatisfaction has grown the present so-called Technical League which has become affiliated with the American Federation of Labor. This band of young engineers and draftsmen hopes to solve the problem of inadequate compensation by means of combination. Other organizations have been proposed and the subject has been discussed in many technical journals.

The interest on the investment of the average young engineer for an education is at first small compared to the net returns of the skilled mechanic or artisan, but this interest increases at a compound rate, while the return of the mechanic remains fixed. In case there is a discrepancy it does not seem that an organization to force better pay from employers would be successful for the following reasons:

The number of employers in any one branch of engineering is small compared to the total number of employers of technical skill. An organization of the rank and file of subordinates in the railway service would constitute the greatest unit which could be assembled, but it is doubtful if such a combination could dictate the policy of other groups. In order to gain an advantage, strikes, boycotts and other subterfuges of unions would be necessary. Success would depend on the ability of the union to control and assimilate the supply of young graduates and the unemployed members in other branches of the profession. The education of the average engineer prepares him to adjust himself to the routine work of almost any position which would be affected by a strike and equips him for an ideal strikebreaker.

There are a great many young engineers who possess too much of the spirit of individuality to be dictated to in matters dealing with their future. Their training will cause them to demand a reason for affiliating themselves with such an organization.

The affiliation with any branch of the American Federation of Labor would tend to blight a possible chance for advancement. The greatest chance for the younger members of the profession to-day is in the field of management of industry. Their position, when starting at the bottom of the ladder, is one that affords abundant opportunity to observe and learn the details of the business. As time passes the chance to become acquainted with the management presents itself and from that time on their temperaments and judgment are the stepping stones upon which they may climb higher or descend to the routine of a strictly technical career. If any member of an engineering department of an industrial organization should cast his lot with the American Federation of Labor, the management of a capitalized industry would never consider him in line for promotion to any position of an executive nature. This would not be discrimination, but simply the right of capital to protect itself.

The average labor union, if given the power, will demand an ever-increasing share in the product of capital and labor, to the extent that capital is often forced to abandon that particular branch of industry. It is only a short time since one of the great labor leaders of the country stated before a large gathering of engineers and capitalists that the only hope the coal operators had to avoid bankruptcy was their organization for mutual protection. He said further that as long as the union, through organization, had the power to force its demand for a larger share in the profit just so long would these demands be made. It is true he was referring to one of the strongest organizations existing, but this sentiment simply indicates the tendency of the times and the growth of socialistic ideas. It is not likely that managers of industry, pressed by such forces, will ally themselves with their competitors.

Returning again to the causes of dissatisfaction we find that the salaried man of to-day is a victim of circumstances. The increase in the cost of living has risen rapidly, but salaries have not been increased proportionately. This is true of all salaried positions. The standard of living and the wants of this class have been elevated to a plane almost level with that of the capitalist whose income is much greater. Intellectual ability and social training are the keys which open the doors of this higher plane and cause an undue financial strain upon those who wish to maintain the standard of their associates.

The young engineer through constant association with the artisan and the mechanic is aware of their income, which has more nearly kept pace with the increase in price of commodities. The discrepancy between the incomes and the amounts necessary to uphold the two standards of living seems too great for placid endurance. This unrest is not confined to individual classes, however, but is worldwide in extent.

Introspection and logic may save many young men from taking some steps which they may regret in later years, and it is for this reason that attention has been called to some of the points to be considered in the solution of this great problem. But, whatever is attempted to ameliorate conditions, let us not forget that we have a certain professional dignity to uphold regardless of cost.

RALPH D. BROWN,
Chief Engineer, O'Gara Coal Company.
Harrisburg, Ill.

Packing-House Floors and Effects of Grease and Water

SIR: Referring to the letter entitled "Packing-House Floors and Effects of Grease and Water" published in the Engineering Record of Jan. 3, page 28, I regret to note that an important typographical error was made about the middle of the page in the paragraph relating to asphalt floors. It states that this type of floor is lighter than "any" other type of the floor. This is obviously incorrect and in my manuscript "many" instead of "any" was used. The statement as its stands reflects on the reliability of the article and I hope that a correction may be made.

Washington, D. C. GEORGE H. SHAW.

CO-OPERATIVE FOREST PROTECTION, as provided for in the Weeks law, is to be carried on in West Virginia. The State and Government each will spend $5,000 a year to protect such portions of the watersheds of the Potomac, Monongahela, Little Kanawha and Great Kanawha Rivers as are most susceptible to fire. Lookout stations with telephones will be established at prominent points, allowing rapid notification of fires. Patrolmen on foot or horseback will cover the lower country.